KAISER HILL COMPANY

ACCELERATED ACTION DESIGN
FOR THE ORIGINAL LANDFILL
ROCKY FLATS ENVIRONMENTAL
TECHNOLOGY SITE

GEOTECHNICAL INVESTIGATION
PHASE 3 STABILITY ANALYSIS
TECHNICAL SUPPORT MEMORANDUM

Project No. 57378.6020
December 2004

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ROCKY FLATS ENVIRONMENTAL TECHNOLOGY SITE

GEOTECHNICAL INVESTIGATION
PHASE 3 STABILITY ANALYSIS
TECHNICAL SUPPORT MEMORANDUM

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EXECUTIVE SUMARY

The purpose of this memorandum is to provide geotechnical input to support design of the accelerated action alternative at the Original Landfill (OLF) at the U.S. Department of Energy's Rocky Flats Environmental Technology Site (RFETS). The primary purpose and focus of the geotechnical investigation has been to develop geotechnical data and perform engineering analyses to a level adequate to support final design of the accelerated action. This has culminated with Phase 3 of the investigation, primarily consisting of the stability analysis of the OLF site with various accelerated action alternatives.

The Phase 2b field investigation work, conducted in June and July 2004, included both drilling and test pit exploration with associated sampling of subsurface materials for geotechnical laboratory testing. It was conducted for the primary purpose of obtaining additional data regarding the properties of the weaker colluvium/slide and weathered claystone bedrock materials underlying the site and controlling the landfill stability. This data, in combination with existing data from previous site investigation work, provides the basis for stability analyses (Phase 3) to support the final accelerated action design.

In support of the current project efforts, a comprehensive hydrogeologic model has been developed for Kaiser-Hill Company by Integrated Hydro Systems, LLC, based on the groundwater monitoring wells and geotechnical borings throughout the RFETS area. Input from this model was used in assigning groundwater levels used in the landfill slope stability analysis for specific geologic cross sections analyzed.

Existing data from previous site investigation work was used to support seismic stability evaluations. Both probabilistic and deterministic site-specific seismic shaking hazards were studied as part of the 1994 work by Risk Engineering. For this OLF Phase 3 evaluation, a value of 0.12g is established for the peak bedrock acceleration when proceeding with methods for the seismic slope stability analyses, and the mean magnitude earthquake of 5.9, for an RMA/Derby source, is established for use in deformation analyses. Detailed explanation of selected procedures and methodology for seismic stability evaluation, including deformation analysis, is provided in this report.

Significant laboratory strength testing of samples of the critical weaker colluvium and weathered claystone bedrock materials provided the primary basis for selecting parameters of these materials for use in the stability analysis. The approach used in selecting these critical materials strength parameters was to assign a lower bound value for all test data within the stress range involved in the analysis for various potential sliding surfaces. Drained strength, appropriate for use in long term static stability analysis, was assigned a design envelope with a 20 degree friction angle. Undrained strength, applied in pseudostatic seismic stability analysis, was assigned a design envelop with a 15 degree friction angle.

Static stability under long-term, steady state conditions, is required to achieve a minimum static safety factor of 1.5. This criteria is typical for earthfill embankments and is required by most agencies and design guidelines, and it is also used for solid waste landfills.

The minimum required pseudostatic safety factor is 1.0 using a seismic coefficient of one half the peak horizontal bedrock acceleration, or 0.06g for the case of the OLF. Seismically-induced permanent displacement shall be less than 12 inches, the generally accepted standard of practice for landfill covers, for the selected design earthquake event, should the pseudostatic safety factor be less than 1.0.

The results of computer-aided stability runs for the various combinations of three critical and representative geologic cross sections, established soil and bedrock density and strength parameters, three geometric conditions, circular arc and sliding block potential failure mechanism searches, and two different groundwater conditions, for both static and seismic conditions, are provided on key summary figures, and show:

- All cases analyzed for existing topographic conditions have safety factor results equal to or less than 1.5 for static analysis and less than 1.0 for pseudostatic analysis.

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- All cases analyzed for an overall 18 percent regrade condition have safety factor results ranging from 1.5 to 1.7 for static analysis and less than 1.0 for pseudostatic analysis.
- All cases analyzed for an overall 18 percent regrade condition have estimated maximum seismically induced permanent displacement results ranging from 5 to 10 inches.
- A surficial stability check of anticipated cover materials indicates that static and pseudostatic safety factors for saturated slope conditions are acceptable.

Some final observations and conclusions regarding aspects of this investigation that are considered conservative to the results of the stability analysis and design of the accelerated action are as follows:

- Strength parameters used for the critical materials controlling stability results are conservative lower bound values of all test data within the anticipated stress range.
- The highest groundwater condition analyzed in combination with seismic loading is quite conservative, as the likelihood of both these conditions occurring simultaneously is low.
- The overall 18 percent regrade design slope is conceptual in nature. Further refinement of this regraded slope with further consideration given to surface water management, groundwater elevations, and bedrock elevations will improve stability issues.

As a result of the data presented and reviewed in this report, the results of static and seismic stability analyses, and past design experience, it is concluded that no stability enhancement beyond slope regrading is required to meet established design criteria for the accelerated action at the OLF.

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1.0 INTRODUCTION

The following sections present information regarding the purpose of this memorandum and the supporting field investigation and engineering analysis. This section also presents site background information and details past investigation efforts.

1.1 PURPOSE

The purpose of this memorandum is to provide geotechnical input to support design of the accelerated action alternative at the Original Landfill (OLF) at the U.S. Department of Energy's Rocky Flats Environmental Technology Site (RFETS).

This document is prepared for Kaiser-Hill Company, LLC, and summarizes the results of Earth Tech Phase 2 and Phase 3 geotechnical investigation activities for accelerated action design. Phase 1 and preliminary Phase 2 work was documented in memoranda dated April 26 and July 27, 2004, respectively. This submittal includes supplementary field exploration and laboratory testing data (Phase 2 investigation), as well as geotechnical engineering analyses and conclusions (Phase 3 investigation), in support of the accelerated action design.

The primary purpose and focus of the geotechnical investigation has been to develop geotechnical data and perform engineering analyses to a level adequate to support final design of the accelerated action. This has culminated with Phase 3 of the investigation, primarily consisting of the stability analysis of the OLF site with various accelerated action alternatives.

1.2 SITE DESCRIPTION AND PROJECT ALTERNATIVES

The OLF site is located south of RFETS Buildings 440 and 460, along the north hillside of a ravine in the Woman Creek drainage area, extending from approximate Elevation 6,040 feet at the top to Elevation 5,950 feet at its base. The OLF site footprint has a maximum length along the east-west direction of approximately 1,700 feet, and approximately 500 feet in the north-south direction, with an approximate area on the order of 20 acres. Existing slope gradients range from approximately flatter than 6 to 1 (horizontal to vertical) to 2 to 1, with a total slope height from the top of the hillside to the Woman Creek drainage of about 90 feet.

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Relative to the specific OLF area of the RFETS, and the associated geotechnical investigation directed toward the Phase 3 stability analysis of the site, aspects of the accelerated action project alternatives involving the landfill area slope and conditions controlling its stability are as follows:

- No action for the landfill, only industrial area regrading (existing topographic conditions for stability analysis).
- Overall 18 percent regraded landfill slope with 2-foot soil cover and drainage improvements (18 percent regrade condition for stability evaluation).
- Landfill slope regrade with buttress at toe for stability enhancement (18 percent regrade with buttress condition for stability evaluation).

A fourth alternative adds an uphill groundwater cutoff wall. Since groundwater modeling has indicated that a cutoff would have relatively minor impact in lowering groundwater levels in the landfill slope and enhancing stability, this was not translated to an additional alternative for stability evaluation.

1.3 SUPPORTING INVESTIGATIONS

The relevant geotechnical and geologic investigations, both previous and current, that were conducted at or adjacent to the RFETS OLF and support this memorandum, are as follows:

- Metcalf & Eddy (M&E) 1995 exploration of the OLF, which reviewed historic air photographs of fill placement (early 1950s to late 1980s), and included drilling and geologic logging of 20 exploratory borings and collecting suitable soil samples for conducting geotechnical laboratory testing, and presenting findings for evaluating causes and extent of landsliding at the site. Depth of borings typically ranged from approximately 30 feet (namely, a few feet into the unweathered bedrock formation) to 150 feet.
- Earth Tech 2002 exploration at the top of the OLF slope into the Rocky Flats Alluvium, including 13 exploratory borings located approximately parallel and at a distance of nearly 100 feet north of the OLF, on the alignment of a potential groundwater diversion system. Exploration included both auger and rock core drilling to depths of 50 to 80 feet and soil/rock sampling, and classification, index, and engineering properties testing in the laboratory.
- Earth Tech 2004 supplemental exploration of the OLF, in support of the accelerated action design and focused on investigating the weaker subsurface materials controlling

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landfill stability (Phase 2b investigation). Exploration included drilling and geologic logging of 11 borings to depths of 42 feet, and excavating and logging 6 test pits.

- Geomatrix Consultants/Risk Engineering 1994 evaluation of subsurface soils conditions at the top of the Rocky Flats Alluvium, including review and summary of available geotechnical data at 60 locations, including a total of approximately 150 borings within the RFETS, including 22 previous soil investigation reports for individual buildings, six geophysical reports, four seismic hazard/risk and geologic investigation reports, and one groundwater monitoring report.

- Risk Engineering 1995 comprehensive evaluation of earthquake sources in the vicinity of the RFETS. Work was performed by a team of consultants and members of academia lead by Risk Engineering (Geomatrix Consultants, EQE International [Dr. K.W. Campbell], University of Utah [Dr. W.J. Arabasz], Stanford University [Dr. A. Cornell], Dr. G.A. Bollinger, 1994), including a state-of-the-art seismic hazard study. Previous geologic and seismicity studies had been conducted by Blume (1974), TERA (1976), Dames and Moore (1981) and Ebasco (1992).

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2.0 FIELD AND LABORATORY INVESTIGATIONS

The most recent geotechnical field and laboratory investigation programs undertaken at the original landfill were for the primary purpose of obtaining additional data regarding the properties of the weaker colluvium/slide and weathered claystone bedrock materials underlying the site and controlling the landfill stability. This data, in combination with existing data from previous site investigation work, provides the basis for stability analyses to support the final design of the accelerated action. The investigation activities were conducted in accordance with the Phase 2b Field and Laboratory Investigation Plan dated June 2004.

2.1 EXPLORATION BOREHOLES AND TEST PITS

The Phase 2b field investigation work, conducted in June and July 2004, included both drilling and test pit exploration with associated sampling of subsurface materials for geotechnical laboratory testing. A focused drilling program was directed toward undisturbed sampling of the weaker subsurface materials susceptible to, or currently involved in, instability, including primarily the colluvium/slide and weathered claystone bedrock materials. Limited test pitting by backhoe excavation at strategic locations was directed toward obtaining a visual look at the colluvium/slide interface with the weathered claystone bedrock surface, and sampling of these weaker subsurface materials as appropriate.

Exploration and sampling locations are shown on Figure 1. Borehole and test pit logs are provided in Appendix A.

Listed below is a summary of the drilling and test pit work:

- Drilling and test pit exploration activities occurred between June 18 and July 14, 2004.
- Exploration boreholes, including some adjacent offset holes for additional sampling or due to difficult drilling conditions, were drilled at or near the 10 locations identified in the investigation work plan (Figure 1). One additional hole was drilled in the vicinity of Test Pit No. TP-5.
- Borehole depths ranged from 14 to 42 feet.
- All boreholes were advanced through the weathered claystone bedrock materials and terminated in relatively unweathered claystone bedrock.

- Undisturbed samples were retrieved during the drilling operations from the various material types encountered, focusing on the colluvium and weathered claystone bedrock materials.

- Continuous dry core was retrieved from all boreholes and saved in core boxes for visual observation.

- Exploration test pits were excavated at or near the 6 locations identified in the investigation work plan (Figure 1).

- Test pits typically ranged from 10 to 15 feet in depth.

- The weathered claystone bedrock material was intercepted in 5 of the 6 test pits, and sampled in 4 of the test pits (Test Pit Nos. 1, 3, 4, and 6).

Field exploration findings are summarized as follows:

- No significant unanticipated conditions were encountered during the Phase 2b field investigation work, relative to conditions anticipated from familiarity with previous site exploration data.

- The field exploration encountered all material types anticipated, including fill, colluvium, valley fill alluvium, severely weathered claystone, moderately weathered claystone, and unweathered claystone. These material types and depths at which they were encountered match up well with the findings from previous site exploration.

- The most critical colluvium/slide and severely weathered claystone bedrock materials were encountered at most of the exploration locations.

- The most unanticipated finding was localized soft, fine-grained alluvial material encountered at one exploration location below the base of the landfill, at Borehole No. BH-9.

2.2 GEOTECHNICAL LABORATORY TESTING

Review of the undisturbed samples and core retrieved during the Phase 2b field exploration work, and formulation of the geotechnical laboratory testing program, occurred between July 12 and 15, 2004. This process included detailed evaluation and selection of samples and procedures for the testing program, including careful review of field data and logs, and visual review of the drilling core and undisturbed samples retrieved for potential testing. This activity involved discussion between the geotechnical engineer and field geologist, and a meeting and review of representative samples for testing between the geotechnical engineer and laboratory testing staff.

The primary focus of the Phase 2b laboratory testing program was the determination of strength of the weaker colluvium/slide and weathered claystone bedrock materials underlying the site and controlling the landfill stability. A range of index properties tests was also performed on selected samples for classification, characterization, and confirmation of field logging. Based on the sample review and testing program formulation process described above, the most critical and also representative samples available were selected for testing.

Listed below are the test procedures and numbers of tests performed for the Phase 2b laboratory investigation:

- Moisture Content (ASTM D2216) - 8 (additional tests part of other engineering properties tests)
- Density (ASTM D2937) - 8 (additional tests part of other engineering properties tests)
- Particle Size Analysis (ASTM D422) - 23
- Atterberg Limits (ASTM D4318) - 17
- Consolidation (ASTM D2435) - 4
- Direct Shear (ASTM D3080) - 27 points
- Consolidated Undrained Triaxial Strength - ICU (ASTM D4767) - 33 points

For the direct shear strength tests specified, 15 points were run on severely weathered claystone materials, 6 points were run on moderately weathered claystone materials, and 6 points were run on colluvium materials. For the triaxial strength tests specified, 18 points were run on severely weathered claystone materials, 6 points were run on moderately weathered claystone materials, 6 points were run on colluvium materials, and 3 points were run on fine grained alluvium materials.

The laboratory testing program described above was completed in September 2004. All Phase 2b geotechnical laboratory test data is provided in a separate volume to this memorandum, referenced in Appendix B.

3.0 SITE CONDITIONS

The following section details regional geologic and seismic conditions, site geologic conditions, site groundwater conditions, landsliding issues, and anticipated seismic shaking. Information from each of these conditions is incorporated into subsequent stability analyses.

3.1 REGIONAL GEOLOGIC AND SEISMIC SETTING

The regional geologic and seismic setting surrounding the OLF are presented in the following section.

3.1.1 Geologic Setting

The OLF is located on the south side of the RFETS, which is in turn located on the western edge of the Colorado Piedmont section of the Great Plains Physiographic Province (Hunt, 1974). The piedmont slopes eastward and is incised by drainages flowing from the Front Range into the Great Plains. The Rocky Flats was formed by erosion of Cretaceous-age (Arapahoe and Laramie) bedrock formations, and subsequent deposition of the Pleistocene Rocky Flats Alluvium atop the resulting eroded surface. The claystone bedrock slopes below the rocky surface were exposed by continued stream erosion through the pediment. Landsliding on these slopes probably commenced at about the middle Pleistocene, shortly after the slopes were initially exposed (Shroba and Carrara, 1994). A more detailed description of the regional geologic history and setting is presented in the Geologic Characterization Report for RFETS (EG&G, 1995).

As described in previous RFETS geologic and seismologic reports (Blume, 1974; Ebasco, 1992; Risk Engineering/Geomatrix, 1994), in general, the lithologic column includes the following:

- Rocky Flats Alluvium, consisting of fan deposits of early Pleistocene age (1 to 2.5 million years) is derived from the Front Range. These deposits are predominantly of bouldery and cobbley, silty, clayey, and sandy gravel nature, ranging in thickness from less than 1 foot to over 100 feet, and averaging 10 feet. Rocky Flats Alluvium is underlain by sedimentary bedrock.
- Sedimentary Bedrock of Cretaceous age (65 to 135 million years) of the Arapahoe Formation, Laramie Formation, and Fox Hill Sandstone, and Pierre Shale, in descending order, which at the RFETS dips generally 1 to 5 degrees to the east, with local variations of up to 20 degrees. The uppermost unit, the Arapahoe Formation is approximately 120 feet thick and consists of claystone with interbedded sandstone and siltstone. The

Laramie Formation consists of clayey shale, sandy shale and claystone, and is approximately 600 to 800 feet thick. The Fox Hill Sandstone is approximately 100 feet thick. The Pierre Shale is approximately 8,000 feet thick.

- Crystalline Bedrock, underlying sedimentary units at the site, at a depth on the order of 10,000 to 13,000 feet.

3.1.2 Seismic Sources and Historic Seismicity

A state-of-the-art evaluation of earthquake sources in the vicinity of the RFETS was performed by a team of consultants and members of academia lead by Risk Engineering (1994), and some of their findings and conclusions are summarized below:

Primary seismic sources that were identified (Risk Engineering Table 2-1 and Figure 2-3) include the following faults, all located within 25 kilometers of the site:

- Golden-Boulder Fault, maximum magnitude 7 to 7-1/2,
- Valmont Fault, magnitude 5-3/4 to 6-3/4
- Walnut Creek Fault, magnitude 5-3/4 to 6-3/4 and
- Rock Creek Fault, magnitude 5-3/4 to 6-3/4

Five areal seismic sources were identified (Risk Engineering Figure 2-2), as follows:

- Denver Basin – Regional Source I, with maximum magnitudes from 5-1/2 to 7 or 5-1/2 to 6, depending whether or not the 1882 Colorado earthquake occurred within this regional source

- Eastern Rocky Mountains – Regional Source II with maximum magnitudes from 5-1/2 to 7 or 5-1/2 to 6-1/2, depending whether or not the 1882 Colorado earthquake occurred within this regional source

- Western Colorado/Rio Grande Rift Source – Regional Source III with maximum magnitudes from 6-1/2 to.7-1/2

- Great Plain Sources – Regional Sources IV and V, with maximum magnitudes from 5-1/2 to 6

The areal sources represent the occurrence of earthquakes which could not be associated with a specific fault.

An additional seismic source was associated with deep-well waste fluid injection, as follows:

- Rocky Mountain Arsenal (RMA)/Derby located approximately 15 to 25 kilometers east of the Rocky Flats, which could generate maximum magnitude earthquakes of 5-1/2 to 7.

The 1994 Risk Engineering study included a comprehensive review of historical records, to provide a data base for statistical evaluation, including pre-instrumental shocks in Colorado, such as the Maximum Historic 1882 Colorado earthquake with an assigned, estimated moment magnitude of 6.4 ± 0.3. However, there is uncertainty as to the source location of this historic event.

The translation of this historic seismic data to selection of a design seismic event is discussed later in this Section 3.

3.2 SITE GEOLOGIC CONDITIONS

As described in the 1995 M&E report, the Original Landfill is located in the Buffer Zone to the south of Building 440 and 460, on the south facing slope, between the edge of the Rocky Flats alluvial terrace and Woman Creek. It is reported, based on review of historic air photographs, that placement of fill commenced during the early 1950s and continued at least into the late 1980s, with much of the waste fill apparently dumped off the edge of the flat alluvial terrace, onto the slope and intermixed with native Rocky Flats alluvium and colluvial materials.

Areal distribution of the surficial geologic units is shown on Figure 2 of the 1995 M&E geotechnical/geologic investigation report, which is reproduced in Appendix C of this memorandum (Figure C1). In addition, Figures 4 through 10 of the M&E report include geologic cross sections A-A' through G-G' showing interpreted surface and subsurface soil and bedrock conditions, which are also included in Appendix C of this memorandum (Figure C2 through C8). Results of the supplementary (Phase 2b) geotechnical field exploration at the site appear to generally confirm subsurface soil conditions depicted by the 1995 M&E report. Phase 2b exploratory borings and test pits (included in Appendix A of this memorandum) were added to the 1995 M&E cross sections (Appendix C).

A brief description of the site geologic units is as follows:

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Waste Fill: Waste fill predominantly consists of sandy and clayey gravel and cobbles (GC) derived from colluvial and Rocky Flats alluvial materials that were mixed with varying concentrations of waste from historical RFETS production activities. It was estimated that the ratio of volume of soils to waste is on the order of 2 to 1, or about 67 percent soil to 33 percent waste. The observed waste included sheet metal, wood, broken glass, plastic, rubber, metal shavings, glass, solid blocks of graphite and graphite sand, concrete, asphalt and portions of 55-gallon steel drums. The fill generally varies from loose to medium dense, generally dry to moist, although occasionally wet when underlain by an impervious material. Waste fill ranged in thickness at boring locations from approximately 2 to 11 feet, although it may locally be as thick as 15 to 20 feet, as shown on interpreted geologic sections. Further, it is anticipated that after potential slope regrading and capping of the original landfill site, some sections may locally include on the order of 25 feet of waste and other fill.

Clean Fill: Clean fill soils were locally found under the road located immediately south of the south interceptor ditch (SID), and as relatively thin cover (generally less than 10 feet in thickness) related to the construction of the buried outfall pipe over the northeastern portion of the OLF, as shown on cross section D-D', E-E', and G-G' (Appendix C).

Colluvium (Qc): These deposits vary from sandy, clayey gravel and cobbles (derived from the Rocky Flats Alluvium) to sandy clay (GC to CL), and are located on slope areas below the Rocky Flats Alluvium. Colluvial materials have reportedly (M&E, 1995) been mobilized by several instances of landsliding, and apparently have slid atop the weathered bedrock, as well as have been incorporated within deeper seated slides.

The coarser-grained colluvium is generally medium dense, while the finer-grained colluvium varies from stiff to medium stiff, although looser, softer and wet colluvium was occasionally encountered during the 1995 M&E exploration. Colluvium ranged in thickness at boring locations from approximately 1 to 13 feet, although it may locally be as thick as 15 feet or slightly thicker, as shown on interpreted geologic section G-G' (Appendix C).

Rocky Flats Alluvium (Qrf): These pediment/fan deposits which comprise the flat alluvial surface of Rocky Flats were generally dense, sandy, clayey gravel with cobbles (GP, GC), with occasional interbedded layers of stiff to hard clays and sandy clays (CL, CH) as well as fine, medium dense to very dense clean and clayey sands (SP, SC). Alluvial materials have reportedly (M&E, 1995) ranged in thickness at boring locations at the top of the slope, from approximately 30 to nearly 50 feet, and generally above Elevation 5,995 feet to 6,010 feet, as shown on interpreted geologic sections A-A' through F-F' (Appendix C).

Geomatrix (1994) conducted a fairly comprehensive characterization of this alluvium with the purpose of evaluating its susceptibility to liquefaction (if any) based on numerous available geotechnical studies previously conducted at the Rocky Flats (namely, field exploration and laboratory test data). Of the 327 soil samples and penetration resistance measurements, roughly speaking one third corresponded to clayey materials (CL), one third in sandy materials (SC, SM), and the other third in gravelly materials (GC, GM). It was concluded that the clayey materials were generally very stiff, and that the sandy and gravelly materials were medium dense to very dense. Geomatrix also reported average groundwater levels within the Rocky Flats Alluvium of 5 to 10 feet below ground surface. Woodward-Clyde Consultants (WCC, 1986) similarly reported groundwater depths of 7 to 15 feet in 5 of 10 exploratory borings. Groundwater within the Rocky Flats Alluvium is interpreted to be perched within the varied and individual layers of more pervious sands or gravel above clay layers or the claystone bedrock.

<u>Valley Fill Alluvium (Qal)</u>: These deposits encountered along Woman Creek vary from medium dense to dense, sandy, silty-clayey gravel with cobbles (GP, GM-GC). Alluvial materials have reportedly (M&E, 1995) ranged in thickness at boring locations at the toe of the slope, from approximately 5 to 7 feet, as shown on interpreted geologic sections A-A' through F-F' (Appendix C). Groundwater in alluvium was found as shallow as 2 feet.

<u>Claystone</u>: The bedrock underlying the OLF predominantly consists of Laramie Formation claystone, with subordinate beds of siltstone and sandstone. Under the landfill, this formation is relatively flat-lying (i.e., near horizontally bedded), and for engineering property evaluation purposes it was characterized, depending on the degree of weathering, as "severely weathered" (sw), "moderately weathered" (mw), or "unweathered" (uw), as part the 1995 M&E investigation. This characterization was adopted by this geotechnical investigation and is summarized as follows:

- Severely Weathered Claystone (CSsw), which represents bedrock that is weathered to the extent that the original rock texture and structure (e.g., bedding, fracturing) is no longer recognizable. This material generally consists of moist to wet, stiff to very stiff (occasionally medium stiff), lean to fat clay, and ranged in thickness at exploration locations from less than 0.5 to 4 feet.

- Moderately Weathered Claystone (CSmw), which represents bedrock that ranges from highly weathered (but showing some discernable structure with typical iron oxide staining) to slightly weathered (nearly fresh, but showing some occasional iron staining). Moderately weathered claystone is usually friable (locally plastic) and soft, typically damp to moist, and of hard consistency, and moderately to highly plastic. Bedding and fracturing (jointing) ranges from massive (without recognizable bedding structure, unfractured) to thinly laminated (parallel bedding surfaces spaced at less than about 0.1 inch) and/or intensely fractured, interbedded with thin laminae of silt and very fine sand. The thickness of the moderately weathered claystone ranged from approximately 2 to 23 feet.

- Unweathered Claystone (CSuw), which represents bedrock that completely lacks iron staining, and represents rock that has little or no hydraulic connection with surficial water. (i.e., water in the upper hydrostratigraphic unit). The strength, hardness, and fracturing characteristics of the unweathered claystone were generally comparable to those of the moderately weathered claystone, although somewhat drier (ranging from damp to dry) and harder to drill. Depth to the top of unweathered claystone was interpreted to range from a minimum of approximately 15 to 20 feet at the toe of the slope to about 50 feet under the Rocky Flats Alluvium, as shown on M&E Sections A-A' through F-F' (Appendix C).

3.3 GROUNDWATER CONDITIONS

The 1995 M&E report concluded that, based on examination of 62 shallow groundwater monitoring wells and geotechnical borings, most groundwater in the study area appears to be perched atop bedrock, within the deeper portions of colluvium and fill overlying bedrock. The source of most groundwater was interpreted to be within the lower portion of the Rocky Flats Alluvium, penetrating the colluvium and/or fill surficial deposits. Based on the previous groundwater level measurements, the shallow groundwater appeared to concentrate in the lower portion of the surficial deposits, and flow downslope near parallel to the ground and bedrock surfaces, as shown on M&E geologic cross sections (Appendix C).

More recently, in support of the current project efforts, a comprehensive hydrogeologic model has been developed for Kaiser-Hill Company by Integrated Hydro Systems, LLC, based on the groundwater monitoring wells and geotechnical borings throughout the RFETS area. The results

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of this hydrogeologic model are the subject of a separate technical support memorandum. Input from the model used in assigning groundwater levels used in the landfill slope stability analysis, for the geologic cross sections analyzed, is included in Appendix D of this memorandum.

In general, groundwater was found to approximately follow the shape of the top of the weathered claystone bedrock profile and to be located within the lower portion of colluvium and fill surficial deposits. When compared to the existing landfill ground surface slope, the groundwater surface was found to locally reach depths of less than 10 feet.

When compared to the alternative regraded slope configuration, modeled groundwater depths for a typical year climate condition are generally 5 to 10 feet below regraded ground surface or greater, with localized areas less than 5 feet. For a wet season climate condition, modeled groundwater was observed to rise. The modeled groundwater elevations used in the slope stability evaluation were those for a mean annual wet-year groundwater level, and a maximum annual wet-year groundwater level. The modeled groundwater profiles representing these two conditions, for the three cross sections evaluated (cross sections B, C and D), are shown in Appendix D.

As summarized previously, Geomatrix Consultants (1994) also reported average groundwater levels within the Rocky Flats Alluvium of 5 to 10 feet below ground surface. Woodward-Clyde Consultants (WCC, 1986) similarly reported groundwater depths of 7 to 15 feet in 5 of 10 exploratory borings. Groundwater within the Rocky Flats Alluvium is interpreted to be perched within the varied and individual layers of more pervious sands or gravel above clay layers or the claystone bedrock.

3.4 LANDSLIDING

The project site area is generally shown as having some potential for landsliding based on preliminary U.S. Geological Survey maps of landslide deposits of the Denver Quadrangle and the Louisville Quadrangle compiled by Colton and Holligan (1975 and 1977, respectively). Colton and Holligan define landslide deposits as masses of earth and rock that have moved downslope as earthflows and slumps that have formed along gravel-capped mesas where springs and seeps have saturated the underlying shaley or clayey parts of the Pierre Shale, the Laramie

Formation, and the Arapahoe Formation (all Upper Cretaceous). In addition, Colton and Holligan also define areas susceptible to landsliding as general slopes steeper than 10 percent, because slopes of only a few degrees on saturated shale have failed. Conversely, slopes steeper than 10 percent that are underlain by sandstone units of the Fox Hill Sandstone (Upper Cretaceous) and the lower part of the Laramie Formation are generally not susceptible to large slope failures.

Landsliding of these slopes probably commenced at about the middle Pleistocene, shortly after the slopes were initially exposed (Shroba and Carrara, 1994). The 1995 M&E geotechnical/geologic investigation concentrated in understanding the potential for landsliding at the site, and included a detailed review of available geologic data and airphoto interpretation, geologic mapping, and exploratory drilling. The geologic map and cross sections developed by this previous investigation, depicting the evidence of previous landsliding, are reproduced in Appendix C of this technical memorandum for reference.

It should also be noted that water from the RFETS facilities was periodically drained on to the landfill area slopes by a ditch (covered prior to 1983) and an outfall pipe constructed in 1983, which likely caused episodes of sliding from 1983 to 1986, after which the outfall pipe was replaced by a buried outfall pipe that drains southeast into the south interceptor ditch (SID).

3.5 SEISMIC SHAKING

Both probabilistic and deterministic site specific seismic shaking hazards were studied as part of the 1994 work by Risk Engineering. The probabilistic approach was used in subsequent calculations, according to federal regulation requirements for landfill cover design, supplemented with deterministic analyses for computation of seismically-induced permanent displacements of slopes, as part of the stability evaluation for this investigation.

Probabilistic analyses integrate overall earthquake magnitudes and locations to calculate a combined frequency of exceeding various ground motion levels. Conversely, deterministic analyses are based on the concept of a single design event. The dominant earthquake may be chosen as the mean magnitude and distance that caused a ground motion level to be exceeded at the chosen return period.

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The dominant seismic source used for deterministic seismic hazard evaluations was a recognizable seismic source that generally dominates earthquake hazard at the RFETS, namely the RMA/Derby, with a mean magnitude of 5.9 and distance of 27 kilometers, resulting in a peak horizontal acceleration in rock of approximately 0.083g (as summarized in Risk Engineering Tables J-3, J-4 and Figures J-15 through J-18). This event was established for permanent slope deformation analysis evaluations for this OLF Phase 3 evaluation.

Further, these analyses were performed for both "rock" and "soil" site conditions. A firm rock profile is defined as corresponding to an average shear wave velocity in the top 100 feet of at least 2,500 feet per second. Peak horizontal acceleration in rock evaluated by Risk Engineering as part of the seismic shaking hazard study for an earthquake event having a median value with 2 percent probability of exceedance in 50 years, which is the regulatory standard, was calculated to be slightly greater than 0.10g. U.S. Geologic Survey maps show a peak horizontal bedrock acceleration value of approximately 0.12g, for the same probability of exceedance.

The project site is in a zone of fairly low potential for major seismic activity. However, the appropriate seismic potential and shaking hazards need to be recognized and accounted for in the accelerated action design. The above seismic shaking evaluation methods, including the selected seismic shaking input criteria, is detailed in subsequent discussions related to the landfill slope potential deformation evaluation, as part of the overall stability analysis.

For this OLF Phase 3 evaluation, a value of 0.12g is established for the peak bedrock acceleration when proceeding with methods for the seismic slope stability analyses, and a design earthquake with a mean magnitude of 5.9 is established for use in the deformation analyses. Further details related to the seismic stability and deformation analyses are described in Section 5 of this report.

4.0 GEOTECHNICAL MATERIAL PROPERTIES

This section details the material properties for the soil and bedrock materials evaluated in the geotechnical evaluation. It includes material characteristics of waste and other fill, Rocky Flats, Alluvium, colluvium and weathered claystone, and unweathered claystone. This section also includes discussions on critical material strengths and seismic strength considerations.

4.1 GENERAL MATERIALS CHARACTERIZATION

The evaluation of the various geologic units made during field investigation, including air photograph interpretation, geologic mapping, logging of exploratory boreholes and test pits, penetration testing, coring, and sampling, was supplemented with geotechnical laboratory testing, including classification, index, and engineering properties testing on selected soil and weathered bedrock samples. Material property profiles versus depth, based on data from the 2004 and 2002 Earth Tech investigations as well as the 1995 M&E investigation, were utilized for general characterization and evaluation of material properties variation. Observations from this data evaluation are discussed in the following sections for general materials characterization.

4.1.1 Waste and Other Fill

Waste fill materials are known to include significant amounts of Rocky Flats Alluvium (possibly as much as 67 percent), construction debris, and other materials. They exhibit blow counts on the order 10 to more than 50 blows per foot (bpf), but most commonly in the range of 10 to 35, and are therefore considered loose to medium dense. Clean fill (used for road and outfall pipe backfill) was not specifically targeted during this investigation, but it is anticipated to range medium dense to very dense.

4.1.2 Rocky Flats Alluvium

Geomatrix Consultants (1994) discussed the clayey, sandy, and gravelly/cobbley nature of this alluvium. Blow counts in the clayey materials average 28 $\pm$ 14 bpf, although several blow counts were cut off at 30 to 50 blows, and, therefore, the reported average blow count value is considered conservative. Blow counts within the sandy materials averaged 38 $\pm$ 14 bpf, and, similarly cut off at 50 blows, the reported average blow count value is considered conservative. Blow counts within the gravelly materials averaged 41 $\pm$ 13 bpf and, similarly cut off at 50

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blows, the reported average blow count value is considered conservative. Based on Geomatrix Consultants evaluation of soil penetration resistance, it is concluded that the clayey (CL, CH) materials are generally very stiff, and that the sandy (SM, SC) and gravelly (GP, GM, GC) materials are medium dense to very dense.

4.1.3 Colluvium and Weathered Claystone

These materials exhibit Plastic Limit (PL) values ranging from approximately 15 to 20 and Liquid Limit (LL) values ranging from approximately 36 to nearly 80, with resulting Plasticity Index (PI) values ranging from roughly 20 to nearly 60. These soils typically classify as fat clay (CH) and less frequently as lean clay (CL), and in the case of the colluvium, they contain sand and gravel in various fractions. The coarse-grained fraction (sands, gravels, and cobbles), are usually less than 20 percent, but occasionally as high as 60 percent.

The bottom of these materials is highlighted by a significant contrast of soil penetration resistance between surficial materials (waste, clean fill, colluvium, and severely weathered claystone) versus the moderately weathered to unweathered claystone bedrock formation, indicating a significant improvement of engineering properties (compressive and shear strength increase, and reduction in compressibility), for materials encountered below the more highly weathered bedrock material. This depth is variable, but is typically about 30 to 35 feet below the existing slope ground surface.

In-place moisture contents and dry unit weights in colluvium were found to typically vary from 15 to 35 percent and 100 $\pm$ 10 pounds per cubic foot (pcf), respectively. When comparing in-place moisture contents with PL and LL values, it is apparent that in-place moisture contents are somewhat higher than the PL, with liquidity indices on the order of 0 to 0.3, suggesting a slightly overconsolidated colluvial material (possibly the result of clay desiccation). Unconfined compressive strength in the colluvium usually varied from approximately 1 to 2.5 tons per square foot (tsf), although values as low as 0.7 tsf and higher than 4.5 tsf were occasionally measured.

Four consolidation tests performed on severely weathered claystone (CSsw) suggested over consolidation ratios approximately in the range of 1.5 to 3.5.

4.1.4 Unweathered Claystone

In-place moisture contents were found to typically range from 5 to 25 percent (or about 10 percent less than overlying materials). When comparing in-place moisture contents with PL and LL values (essentially in the same general range of those for the overlying colluvium and weathered claystone), it is apparent that in-place moisture contents are usually less than, or about equal to PL values. Consequently, liquidity indices were commonly less than zero, indicating their overconsolidated nature (namely, stronger and less compressible engineering characteristics). Consistent with the latter comparison, unconfined compressive strength in moderately weathered to unweathered claystone usually varied from approximately 10 to 25 tsf, although values as low as 5 tsf and higher than 35 tsf were occasionally reported.

4.2 CRITICAL MATERIAL STRENGTH

As discussed previously, the primary focus of the most recent Phase 2b field and laboratory investigations has been to obtain additional data regarding the properties, primarily engineering strength, of the weaker colluvium/slide and weathered claystone bedrock materials underlying the OLF site and controlling the landfill stability. The numbers and types of strength tests performed, as well as on which type of material the various tests were conducted, was summarized in Section 2.2. The results of all the strength testing performed for the Phase 2b investigation are provided and summarized on Figures 2 through 6. For each type of strength test result, the data for all tests on colluvium/slide and weathered claystone materials is compiled on one figure, for summarization and comparison purposes.

Figures 2 and 3 present triaxial shear test, drained strength test data, which is appropriate for use in long term static stability analysis. Figures 5 and 6 present triaxial shear test, undrained strength test data, from the same strength tests on the various samples listed, which is appropriate for use in short-term loading conditions, such as seismic shaking. Figure 4 presents both peak and residual strength test data from direct shear testing, according to the method providing primarily drained strength results.

The difference between the two triaxial drained strength test data summaries, Figures 2 and 3, and between the two triaxial undrained strength test data summaries, Figures 5 and 6, is the

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presentation of the data according to a couple of different, commonly selected sample failure criteria. Figures 2 and 5 present strength data based on a maximum principal stress ratio sample failure criteria. Figures 3 and 6 present strength data based on a 5 percent strain sample failure criteria. The summaries indicate that the results are very much the same for the two different criteria.

A lower bound strength envelope for all Phase 2b investigation tested colluvium/slide and weathered claystone critical materials is superimposed on the test data summaries for both drained, effective stress strength (Figures 2, 3, and 4) and undrained, total stress strength (Figures 5 and 6), respectively.

When reviewing Figures 2, 3, 5, and 6, it can be seen that the laboratory samples demonstrated a significant cohesion value that contributes to the overall material strength. Figure 2 shows cohesion ranging from 200 pounds/square foot (psf) to 600 psf with an average of 410 psf; Figure 3 shows 150 psf to 700 psf with an average of 425 psf; Figure 5 shows 150 psf to 600 psf with an average of 420 psf; and Figure 6 shows 100 psf to 800 psf with an average of 510 psf. The lower bound strength envelope, which is superimposed on each figure, as a conservative approach, represents zero cohesion and a low enough friction angle such that all strength values within the anticipated stress range are above this lower bound.

4.3 SEISMIC STRENGTH CONSIDERATIONS

Beyond the undrained strength properties determined from the strength tests discussed above, assessment of potential loss of undrained strength as a result of seismic ground shaking is another important consideration for the stability evaluation of the landfill slope. In general, materials underlying the OLF at the RFETS are not expected to be susceptible to significant pore water pressure buildup during seismic loading, or exposed to drastic reduction in cyclic shear strength during cycling loading from seismic shaking. A summary of material properties that lead to indicate their cyclic strength behavior is provided below.

Fill materials, when compacted would not be susceptible to a significant loss of strength, whether or not they are of a cohesive nature. Uncompacted fill, such as the OLF waste mixed with significant amounts of Rocky Flats Alluvium, although it would generally not be as dense as in its natural condition, contains significant amounts of clay, and thus is not expected to lose significant amounts of strength during shaking. It is possible, however, that localized pockets, where uncompacted cohesionless granular material may have become saturated, could be adversely affected by seismic shaking. Even in this case, the situation would be considered to have limited lateral extent and thickness and would not be anticipated to constitute a generalized condition under significant portions of the landfill site.

Rocky Flats Alluvium underlying the upper portions of the OLF slope, while containing a significant fraction of granular materials, are fairly dense, and also include a clay matrix that significantly reduces, if not completely eliminates, the potential for a rapid increase in pore water pressure due to cyclic loading. This is consistent with the findings of Geomatrix Consultants (1994), indicating that sandy and gravelly fractions were generally dense, with blow counts on the order of 38 $\pm$ 14 bpf and 41 $\pm$ 13 bpf, respectively. Similarly, clayey soil fractions were very stiff with blow counts on the order of 28 $\pm$ 14 bpf.

Colluvial materials, which contain significant amounts of cohesive soils (clay) and claystone bedrock materials, are highly cohesive and very stiff to hard, and therefore are not anticipated to be prone to a significant amount of pore water pressure buildup and loss of shear strength during seismic shaking.

As a result of these soil and bedrock physical properties, the seismic stability evaluation discussed in the next section, which uses undrained strength properties for the critical clay type colluvium/slide and weathered claystone bedrock materials, is considered to be based on conservative analysis parameters.

5.0 STABILITY ANALYSIS

This section discusses the basis, results, observations, and conclusions of the stability analyses performed to support design of the OLF accelerated action. Two primary components of the analyses are associated with static long-term loading conditions and potential seismic short-term loading conditions applied to the landfill slope. These two different aspects of stability are addressed throughout the various discussions for this section. The key bases and results of the entire stability analyses are provided on Figures 7, 8, and 9. Supporting results from computer-aided analyses of static and pseudostatic methods for all cases and conditions analyzed, as summarized on Figures 7, 8, and 9, are provided in Appendix E. Deformation analysis methods, performed as part of the seismic stability analysis, are discussed in detail in Appendix F.

5.1 CRITERIA

Criteria for the static stability analysis and seismic stability analysis are presented in the following sections. This includes regulatory guidance for seismic evaluation procedures.

5.1.1 Static Stability

Static stability under long-term, steady state conditions, evaluated in general accordance with conventional two-dimensional limit equilibrium analysis, is required to achieve a minimum static safety factor of 1.5. This value is typical of earthfill embankments and is required by most agencies and design guidelines, and it is also used for solid waste landfills.

5.1.2 Seismic Stability

Generally acceptable methods of slope stability analysis for assessing the seismic stability of earthfills, including in highly seismic areas of the western United States, are summarized below. These procedures are described in guidelines implemented by several state agencies (i.e., California Division of Mines and Geology [CDMG], 1997). In recent years, these procedures were extended to solid waste landfill structures once appropriate parameters for the analysis of landfills were developed (Kavazanjian, 2002; Bray, 1995).

- The pseudostatic stability analysis is a method that may be used in conjunction with a predetermined horizontal seismic coefficient. The seismic coefficient results in an "equivalent" static horizontal acceleration at the center of gravity of a potential sliding earthfill mass in a conventional limit-equilibrium analysis. This is the simplest approach to a dynamic slope stability calculation, and is one of the most often used in current practice and is generally considered to be a conservative approach.

  Although there is no specific guidance regarding the selection of seismic coefficients in pseudostatic analyses for solid waste landfills, pseudostatic slope stability analysis is often performed using a seismic coefficient estimated from procedures developed for earth embankments.

  A range of seismic coefficients and pseudostatic factors of safety, that have been used in engineering practice and referenced in the literature for earthfill structures, generally fall within a trapezoidal area as shown on Figure 1 of CDMG (1997) guidelines (reproduce as Figure F1 in Appendix F of this report), for jurisdictions where pseudostatic coefficients have not been adopted by the lead agency. This figure presents a summary of the recommended values of the seismic coefficient for the ranges of factor of safety and earthquake parameters presented in publications by Seed (1979) and Hynes & Franklin (1984). Seismic coefficients as high as one half of the peak horizontal acceleration in rock have been used, in combination with pseudostatic factors of safety of 1.0 to 1.15 for earth structures.

  It is also noted that a pseudostatic analysis is not considered necessary in cases where the static factor of safety is at least 1.7 for earthfill structures (Hynes and Franklin, 1984).

- A simplified seismically-induced permanent displacement analysis of earthfill slopes, which includes design chart solutions, such as those proposed by Makdisi and Seed (1978), based on previous work by Newmark (1965), is a secondary method used in seismic stability analysis when pseudostatic analysis is an inadequate model.

  The original Newmark procedure involves calculation of the yield acceleration, defined as the inertial force required to cause the static factor of safety to reach 1.0 from the traditional limit-equilibrium pseudostatic analysis. The procedure uses a design earthquake strong motion record and calculates cumulative displacements above the yield acceleration.

  Makdisi and Seed's procedure seeks to define seismic embankment stability in terms of acceptable deformation in lieu of conventional factors of safety, using a modified Newmark analysis. This method presents a rational approach to determine the yield acceleration, including dynamic characteristics and deformability of the fill slopes, and average acceleration of the potential sliding mass. Design curves are used to estimate the permanent earthquake-induced deformations of embankments 100 to 200 feet high, based on previous well-documented cases analyzed by more sophisticated techniques. These methods have been applied to solid waste landfills and highway embankments.

Additional details of the Makdisi and Seed procedure, which has been selected for the seismic analysis of the OLF, have been summarized in Appendix F of this report.

Further work on amplification or deamplification of acceleration potential of landfills was conducted Bray et al. (1998), by including not only the effect of the fundamental period and dynamic parameters of solid waste landfills in the evaluation of the maximum horizontal acceleration, but also the predominant period of the rock motion.

- More complex deformation analyses include numerical methods, such as the use of dynamic finite elements (such as QUAD4) or finite difference mathematical models, or one-dimensional (such as SHAKE) analyses, for selected acceleration time histories. These more complex analyses have been used in highly seismic areas of the western United States for structures that pose high risk to human life and property, where the above indicated "simplified" procedures (pseudostatic analysis, simplified displacement analysis) were either not applicable or did not yield conclusive results. This last category of analysis methods is not considered necessary for the OLF site.

In addition to selection of the appropriate sophistication level of the above standard methods being part of the analysis criteria, regulatory requirements and guidelines also can control analysis criteria. As summarized in Earth Tech's memorandum dated May 26, 2004 (Slope Stability Evaluation – Seismic Issues), State of Colorado hazardous waste regulations (Colorado Code of Regulations [CCR] 1007-3) and solid waste regulations (Colorado Code of Regulations [CCR] 1007-2) are generally silent regarding the seismic stability evaluation and design of landfills. These regulations are consistent with the Code of Federal Regulations (CFR) for Hazardous Wastes 40 CFR Parts 258 and 260-279.

Though there are no specific guidelines regarding the seismic analysis of the landfills at RFETS, the following paragraphs summarize examples of seismic design guidelines that have been developed for high-risk structures such as dams.

- The Colorado rules and regulations for dam safety and dam construction state:

  1. The minimum acceptable pseudo-static stability analysis factor of safety is 1.0, and shall be attainable using a pseudo-static load coefficient of one-half the predicted peak bedrock acceleration (g's), but not less than 0.05.

  2. For those Class I dams, and large and intermediate Class II dams, for which a pseudo-static analysis is not appropriate, as determined by Rule 5.A. (6)(j)(IV), a deformational analysis shall be performed in a manner acceptable to the State

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Engineer. The freeboard remaining due to deformation of the dam shall not be less than three feet.

- USCOLD (1999) states that "If the embankment or the foundation materials are not susceptible to [significant] loss of strength or stiffness [i.e., liquefaction], and if the level of ground motion to be considered does not exceed 0.40g to 0.50g, then simplified methods may be sufficient to estimate the permanent deformations potentially induced by the ground motion."

- Utah (2002) states that "For a maximum acceleration of 0.2g or less, or a maximum acceleration of 0.35g or less if the embankment consists of clay on clay or bedrock foundation, a pseudostatic coefficient which is at least 50 percent of the maximum peak bedrock acceleration at the site should be used in the stability analysis. The minimum factor of safety in an analysis should be 1.0." If the ground shaking noted above is exceeded: "a deformation and settlement analysis should be performed to estimate anticipated total crest movement."

- Washington (1993) notes that seismic analyses are not required if all of the following are met: "1) The dam is well-built (densely compacted) and peak accelerations are 0.2g or less, or the dam is constructed of clay soils, is on clay or rock foundations and peak accelerations are 0.35g or less; 2) The slopes of the dam are 3 horizontal to 1 vertical or flatter; 3) The static factors of safety of the critical failure surfaces involving the crest .... are greater than 1.5 under loading conditions expected prior to an earthquake; and 4) The freeboard at the time of the earthquake is a minimum of 2 to 3 percent of the embankment height (not less than 3 feet) ....".

- State of California (Department of Conservation, Division of Mines and Geology) Special Publication 117: Guidelines for Mitigating Seismic Hazards in California, refers the selection of the Seismic Coefficient to research by the U.S. Army Corps of Engineers (Miscellaneous Paper: GL-84-13: "Rationalizing the Seismic Coefficient Method," authored by Hynes and Franklin, 1984) which provided amplification factors to be used when considering the crest of an embankment in comparison with amplifications at the base, with the intention of identifying those embankments which could be expected to experience unacceptable deformations. They suggested using one-half the bedrock acceleration applied to the embankment crest with an acceptable factor of safety greater than 1.0, and limited the assessment to earthquakes of less than magnitude 8 with nonliquefiable materials comprising the embankment. A reduction on material static undrained shear strengths up to 20 percent may be applicable depending on the nature and cyclic behavior of soils.

It should be noted that the above-listed requirements pertain to high risk dam structures whose failure could result in immediate loss of human life and/or significant property damage. The RFETS OLF is not this type of high risk structure.

Considering the project site setting, geologic conditions, standard of practice, and regulatory requirements, the following seismic stability analysis criteria were adopted for the OLF site:

- Minimum required pseudostatic safety factor of 1.0 using a seismic coefficient of one half the peak horizontal bedrock acceleration. For the case of the OLF, one-half of the peak horizontal bedrock acceleration represents 0.06g.

- Seismically-induced permanent displacement less than 12 inches, the generally accepted standard of practice for landfill covers, for the selected design earthquake event, should the pseudostatic safety factor be less than 1.0.

5.2 BASIS OF ANALYSIS

The Phase 3 stability analysis was performed on the following bases:

- Use of existing geologic cross sections from the M&E report. The most critical section through the landfill is not obvious; analyses were performed on the three existing cross sections encompassing the waste and past slide materials across the entire hillside slope which are believed to bracket the typical and most critical stability conditions (M&E geologic cross sections B-B', C-C', and D-D').

- Use of density and strength material parameters established on Figures 7, 8, and 9. Material properties were selected based on Phase 2b field and laboratory geotechnical data collected as part of this investigation (Figures 2 through 6, Appendices A and B), supplemented by the results of previous investigations at the project site by Metcalf & Eddy (1995). Strength values represent a lower bound friction angle with zero cohesion, which is a lower bound for all strength values within the anticipated stress range.

- Use of groundwater levels generated from the hydrogeologic modeling described earlier (Appendix D).

- Comparison of analyses factor of safety results to minimum required criteria of 1.5 for static conditions and 1.0 for seismic conditions using a pseudostatic analysis. Comparison of estimated seismically induced permanent displacement to maximum allowed 12 inches for pseudostatic analysis cases yielding a safety factor less than 1.0.

5.3 CONDITIONS ANALYZED

Geometric conditions analyzed in the Phase 3 stability analyses associated with the project alternatives, as depicted on Figures 7, 8, and 9, are as follows:

- Existing ground surface and slope, per the M&E geologic cross sections.

- Overall 18 percent regraded cover slope superimposed over existing ground surface topography.
- Stability buttress at the toe of the landfill with the 18 percent regraded slope.

For each of the various variable conditions used as the bases of analyses, the following conditions were analyzed, in terms of general mechanisms of potential sliding and the approach to searching for potential failure surfaces with minimum factors of safety for each case analyzed:

- Circular failure surface search through all materials in the landfill slope above the unweathered claystone bedrock.
- Sliding block failure surface search within the critical colluvium/slide and weathered claystone bedrock materials, as depicted on the M&E geologic cross sections.
- Shallow sliding potential in regraded cover materials.

For each of the various geometric conditions and potential sliding mechanisms considered, the stability was analyzed for two groundwater conditions, as follows:

- Average wet year climate conditions (Appendix D).
- 100-year wet year climate conditions (Appendix D).

For each of the various conditions and cases considered, analyses were performed for both static and seismic conditions. Seismic conditions were analyzed initially using a pseudostatic analysis approach with a horizontal force seismic coefficient of 0.06g. The simplified deformation analysis was also employed for the various cases analyzed.

In addition, a check was made of surficial sliding potential in regraded cover materials based on saturated ground conditions.

5.4 METHODOLOGY

Stability analyses of the landfill slope for various project alternatives were conducted in the following evaluation/computational sequence:

- Static slope stability analysis and selection of potential critical slip surfaces.

- Pseudostatic slope stability analysis and evaluation of yield acceleration seismic coefficient.
- Determination of average acceleration of potential slide mass under selected design conditions for seismic shaking.
- Estimation of seismically induced permanent displacement for the selected design earthquake event using simplified deformtion analysis.

These four stages of the analysis are described in the following sections.

To assess permanent, long-term steady state stability of the landfill, conventional two-dimensional limit-equilibrium stability analyses methods were performed for static conditions. The limit equilibrium methods were also employed for an initial, simplified assessment of seismic stability using the assigned seismic coefficient of 0.06 g for pseudostatic conditions. Factors of safety against sliding using circular arc and sliding block failure surfaces were computed for both the static and pseudostatic analyses. For the approach taken of assigning a uniform lower bound strength to the most critical colluvium/slide and weathered claystone materials, which is conservative, and considering the geometry of the landfill slope and subsurface material layers, either circular arc or sliding block failure modes could be critical, and these methods of modeling potential critical failure surfaces used for the stability analyses are appropriate.

The landfill slope for the various conditions previously discussed was computer-analyzed for circular arc failure modes using Bishop's modified method and for sliding block failure modes using Janbu's modified method. These methods incorporate, as basic input data, the geometry of the slope and subsurface material layers, unit weight and shear strength properties of the soil and bedrock materials, and the distribution of boundary and internal water forces. After a failure surface has been assumed, the soil mass above the sliding surface is divided into a series of vertical slices. Forces acting on each slice include the earth pressures on its sides, water pressures on its sides and bottom, effective earth pressures with associated friction acting on the assumed sliding surface, and cohesion along the sliding surface. Various trial failure surfaces are analyzed until a minimum factor of safety is obtained for the case being studied.

The modified Bishop and Janbu methods are generally conservative and efficient methods of analysis used for initial extensive screening of potential slip surfaces. In addition, the Spencer method, being a more rigorous method of slope stability analysis, was used to check the most critical cases identified by searching methods employed by the modified Bishop and Janbu methods. Spencer's method satisfies both force and moment equilibrium of the sliding mass, whereas the modified Janbu and Bishop methods satisfy only force and moment equilibrium, respectively. Further, the most critical slope stability results were also independently evaluated as part of normal quality control procedures.

The various computational methods discussed above were performed by computer analyses. The computer program PC STABL 5M, developed at Purdue University, was used to perform the stability analyses. The program performed automatic searches of different potential failure surfaces to determine the most critical surface having the lowest factor of safety for the condition being analyzed.

For seismic stability analysis required beyond the initial, simplified pseudostatic analysis check, the Makdisi and Seed procedure for computation of seismically induced permanent displacement was employed . The methodology of this procedure, which is widely accepted in geotechnical earthquake engineering and state-of-practice in seismic stability evaluation of landfill slopes, is detailed separately in Appendix F of this memorandum.

For the surficial stability check of anticipated cover materials, an infinite slope analysis method of calculation was used.

5.5 RESULTS

The results of computer-aided stability runs for the various combinations of three cross sections, established soil and bedrock density and strength parameters, three geometric conditions, circular arc and sliding block potential failure mechanism searches, and two different groundwater conditions, for both static and seismic conditions, are provided and summarized on Figures 7, 8, and 9 for the M&E geologic sections B-B', C-C', and D-D', respectively. The results can be summarized as follows:

- The analysis of geologic section B-B' appears most critical. However, there are only subtle, minor differences in minimum safety factor results between the various cross sections analyzed.

- Results obtained from analyses of potential sliding block surfaces are slightly more critical, by only a difference of 0.1 on the safety factor, or the same as results of the analyses of potential circular arc sliding surfaces in all cases analyzed. This is consistent with the geometric configuration of the critical colluvium/slide and weathered claystone bedrock material layers oriented beneath the long flat landfill slope.

- For the two climatic conditions modeled by two slightly different groundwater levels, results indicate a maximum difference in safety factors of 0.1.

- All cases analyzed for existing topographic conditions have safety factor results equal to or less than 1.5 for static analysis and less than 1.0 for pseudostatic analysis.

- All cases analyzed for the 18 percent regrade condition have safety factor results ranging from 1.5 to 1.7 for static analysis and less than 1.0 for pseudostatic analysis.

- All cases analyzed for the 18 percent regrade with buttress condition have safety factor results ranging from 1.7 to 1.9 for static analysis and ranging from 0.9 to 1.0 for pseudostatic analysis.

- All cases analyzed for existing topographic conditions have estimated maximum seismically induced permanent displacement results ranging from 10 to over 12 inches.

- All cases analyzed for the 18 percent regrade condition have estimated maximum seismically induced permanent displacement results ranging from 5 to 10 inches.

- All cases analyzed for the 18 percent regrade with buttress condition have estimated maximum seismically induced permanent displacement results ranging from 3 to 5 inches.

- For the surficial stability check of anticipated cover materials, static and pseudostatic safety factors for saturated slope conditions are acceptable (Appendix E).

In addition to the summary of specific results for each case and condition analyzed, in terms of safety factor against sliding and maximum permanent displacement for seismic shaking, all analyses input variables are listed and illustrated on the results Figures 7, 8, and 9. Selected material parameters are listed in a summary table against a key for each subsurface material type. Geologic cross sections reflecting the three project alternative geometric conditions analyzed are provided adjacent to associated stability analyses results and depicting the distribution of hillside materials and groundwater levels. On these geologic sections, for each of the geometric conditions analyzed, typical critical circular arc and sliding block surfaces are illustrated.

Backup of all computer runs showing both the critical sliding surface identified and all surfaces analyzed in the analysis search in a graphic form similar to the cross sections on Figures 7, 8, and 9, for all cases and conditions computed, are provided in Appendix E, organized to correspond to the summary of results on Figures 7, 8, and 9.

5.6 OBSERVATIONS AND CONCLUSIONS

Based on the findings of this geotechnical investigation and specifically the results of the stability analysis performed for the accelerated action alternatives, major observations and conclusions are as follows:

- The primary factor controlling the stability of the existing landfill slope and any regrading modification to it, for both local shallow instability and overall deeper instability potential, is the strength of the colluvium/slide and underlying weathered claystone bedrock materials beneath the landfill site.
- Groundwater conditions within the landfill hillside slope play a significant role in stability conditions from the standpoint of both effect on material strength of the clay type materials comprising the colluvium and weathered bedrock and hydrostatic loading conditions within the landfill slope.
- The criteria used in this analysis of 1.5 factor of safety for the static condition, 1.0 factor of safety using one-half of the peak bedrock acceleration for pseudostatic analyses, and permanent seismically-induced deformations less than 12 inches are consistant with guidance as outlined in Section 5.1.
- The current, more obvious existing evidence of local and surficial instability at the site, of lesser consequence, will be mitigated by improved control of surface water and improvement of material type and strength in slope regrading planned for the accelerated action.
- The critical potential sliding mechanism for lower probability, more massive and deeper instability, which would be of greater consequence, is a large sliding block configuration or a broad circular arc surface involving a majority of the slope with the sliding surface within the weakest colluvium and weathered claystone bedrock matetrials.

- All conditions analyzed for modifications to the landfill slope as part of accelerated action alternatives, either by regrading the slope to the overall 18 percent configuration or by regrading with a stability enhancing buttress, meet or exceed the minimum required safety factor of 1.5 for long term static conditions and would limit maximum seismically induced permanent displacement from seismic shaking under design seismic conditions to less than the maximum 12-inch established design criteria.

- A buttress at the toe of the landfill slope provides enhancement to the overall landfill slope stability, but very subtle improvement for the size and configuration analyzed, approximately 20 feet high, extending about 50 feet beyond the existing slope toe, with a 2.5 to 1, horizontal to vertical, side slope.

- The results of the static and seismic stability analyses do not conclude that stability enhancement beyond the slope regrading condition is required.

Some final observations and conclusions regarding aspects of this investigation that are considered conservative to the results of the stability analysis and design of the accelerated action are as follows:

- Strength parameters used for the critical materials controlling stability results are conservative lower bound values of all test data within the anticipated stress range.

- Neglecting cohesion in the somewhat overconsolidated clay type colluvium and weathered bedrock materials, as established in material parameter selection, particularly for the undrained strength used for short term seismic loading, is conservative to the stability analysis results.

- The highest groundwater condition analyzed in combination with seismic loading is quite conservative, as the likelihood of both these conditions occurring simultaneously is low.

- The 12-inch maximum displacement criteria for seismically induced deformation could be considered conservative, as only a soil cover, with no deformation sensitive design components, such as synthetic liners and piping systems, is anticipated for the accelerated action design.

- The 18 percent regrade design slope is conceptual in nature. Further refinement of this regraded slope with further consideration given to surface water management, groundwater elevations, and bedrock elevations will improve stability issues.

5.7 CONCEPTUAL ACCELERATED ACTION DESIGN

As a result of the data presented and reviewed in this report, the results of static and seismic stability analyses, and past design experience, it is concluded that no stability enhancement beyond slope regrading is required to meet established design criteria for the accelerated action at the OLF.

6.0 REFERENCES

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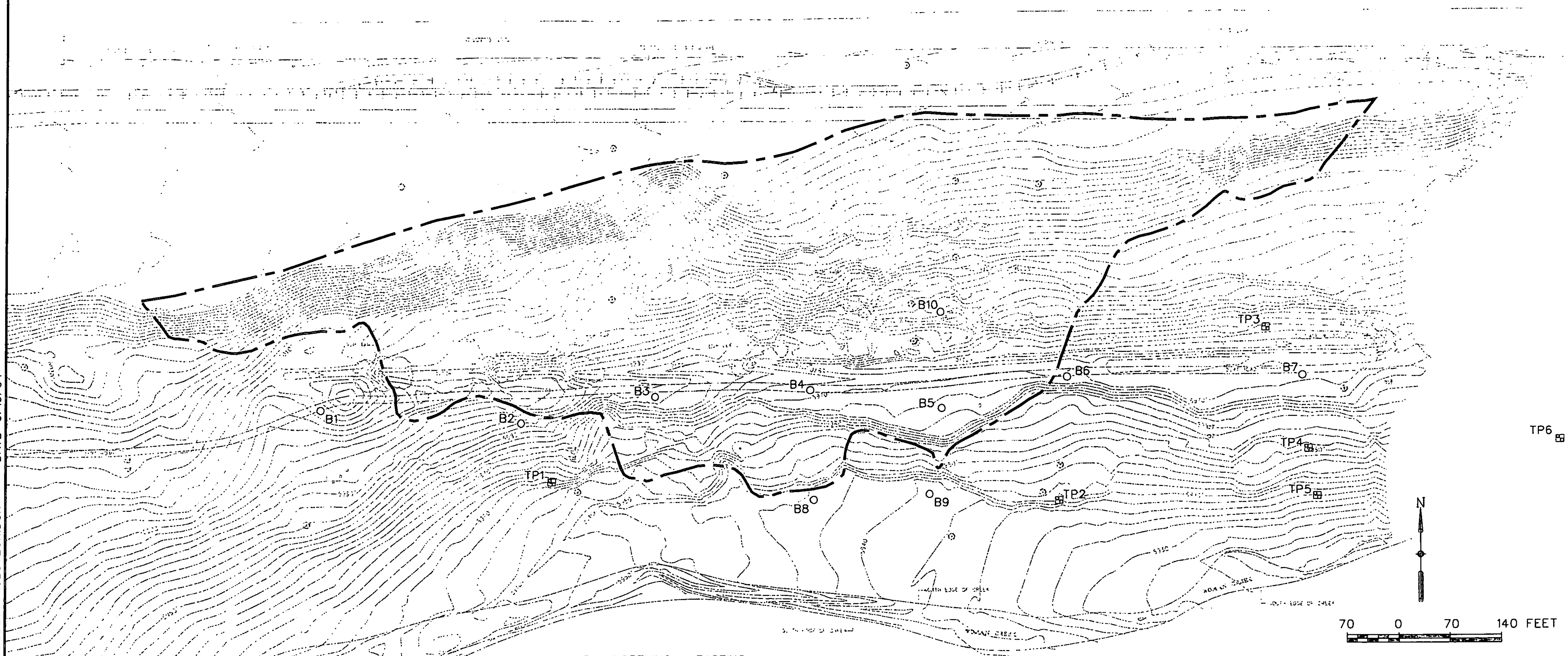

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B5	747673.6	2081992.8
B6	747715.6	2082165.6
B7	747718.1	2082487.5
B8	747544.3	2081816.6
B9	747553.3	2081975.5
B10	747807.8	2081991.1
TP1	747570.4	2081455.0
TP2	747543.6	2082153.4
TP3	747783.9	2082436.9
TP4	747614.6	2082495.5
TP5	747547.8	2082506.9
TP6	747627.5	2082836.3

LEGEND

- UNDERGROUND GAS LINE MARKER
- MONITORING WELL
- CONCRETE PAD
- UTILITY POLE
- UTILITY POLE (STUB)
- OVERHEAD WIRE
- RAILROAD TRACK
- LIMIT OF WASTE

PHASE 2b - PROPOSED ADDITIONAL FIELD INVESTIGATION

- O GEOTECHNICAL BOREHOLE (SEE NOTE BELOW)
- BACKHOE TEST PIT

NOTE: UP TO 2 ADDITIONAL BOREHOLES ASSUMED, ADJACENT TO SELECTED LOCATIONS SHOWN FOR ADDITIONAL SAMPLING NEEDS. B8 AND B9 SUBJECT TO ACCEPTABILITY FOR DRILLING AT THESE LOCATIONS. B8, B9, AND B10 SUBJECT TO TRUCK MOUNTED DRILL RIG ACCESSIBILITY.

EARTH TECH

FIGURE 1
ORIGINAL LANDFILL
GEOTECHNICAL INVESTIGATION
SAMPLING LOCATIONS
ROCKY FLATS ENVIRONMENTAL TECHNOLOGY SITE
GOLDEN, COLORADO

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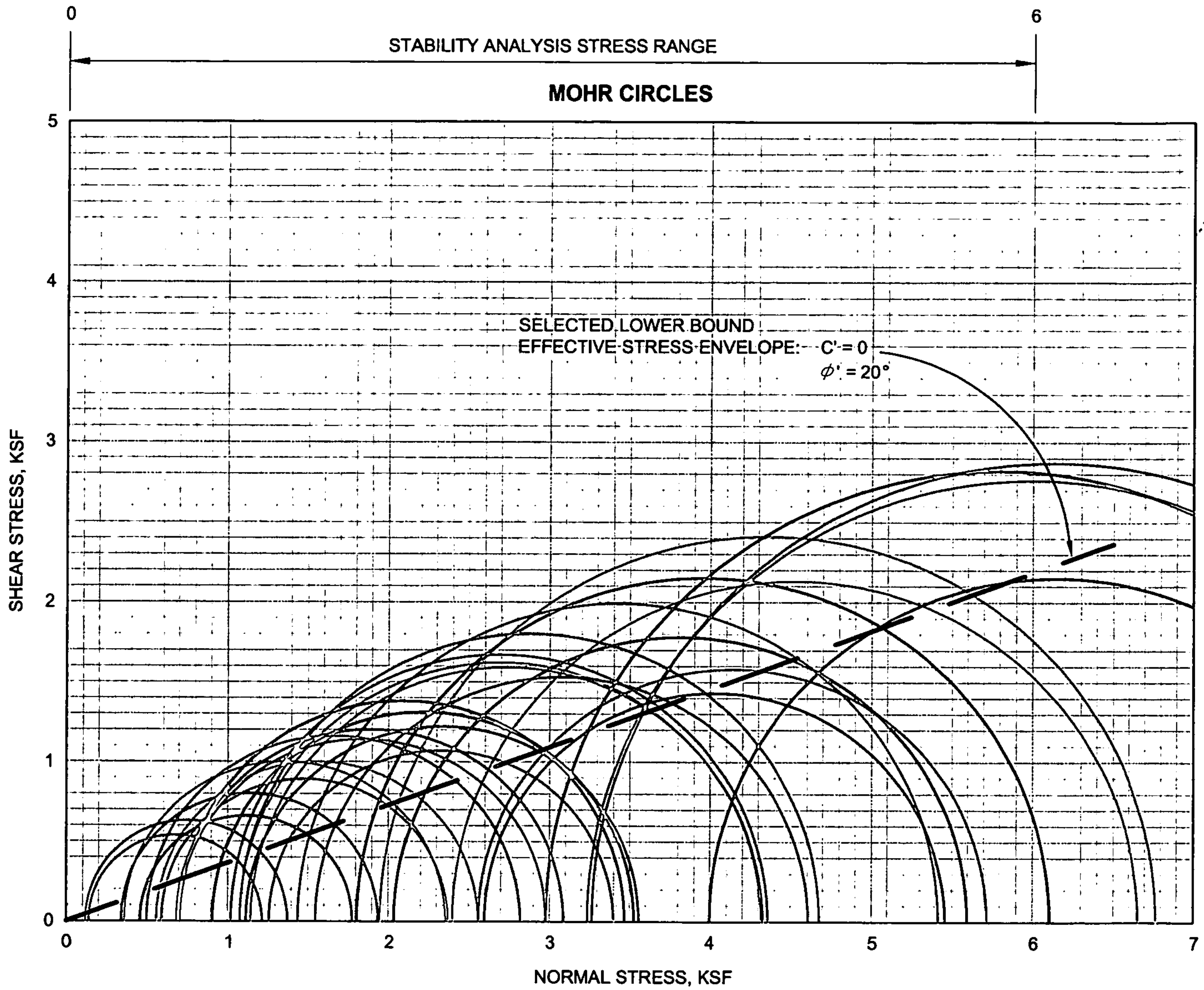

ICU TRIAXIAL TEST RESULTS

KEY	MATERIAL [1]	LOCATION	SAMPLE	DEPTH (feet)	USCS [2]	DENSITY (pcf)	DRAINED STRENGTH [3] COHESION (psf)	DRAINED STRENGTH [3] FRICTION ANGLE (degrees)
——	CSSW	TP1	L1 L2 L3	14 14 14		125 127 125	300	30
——	CSSW	TP4	L1 L2 L3	10 10 10		121 122 127	400	15
——	CSSW	TP6	L1 L2 L3	7 7 7		126 126 130	200	34
——	CSMW	B3	S2	18-20.5	CH	130 129 127	300	17
——	Qc	B4	S2	12-14.5	CH	125 120 122	500	15
——	CSSW	B4	S3	14.5-17	CH	129 125 125	500	22
——	CSSW	B6	S1	11-13.4	CH	123 128 124	600	20
——	CSSW	B7	S1	13-15	CH	128 128 127	400	24
——	Qc	B8	S1	6-8.2		120 121 122	300	30
——	CSMW	B7	L7 L8 L9	17.5-18 18-18.5 18.5-19	CH	122 125 120	600	19

[1] Qc = COLLUVIUM/SLIDE, CSSW = SEVERELY WEATHERED CLAYSTONE, CSMW = MODERATELY WEATHERED CLAYSTONE

[2] UNIFIED SOIL CLASSIFICATION, BASED ON GRADATION AND ATTERBERG LIMITS

[3] BASED ON MAXIMUM PRINCIPAL STRESS RATIO FAILURE CRITERIA, EFFECTIVE STRESS PARAMETERS

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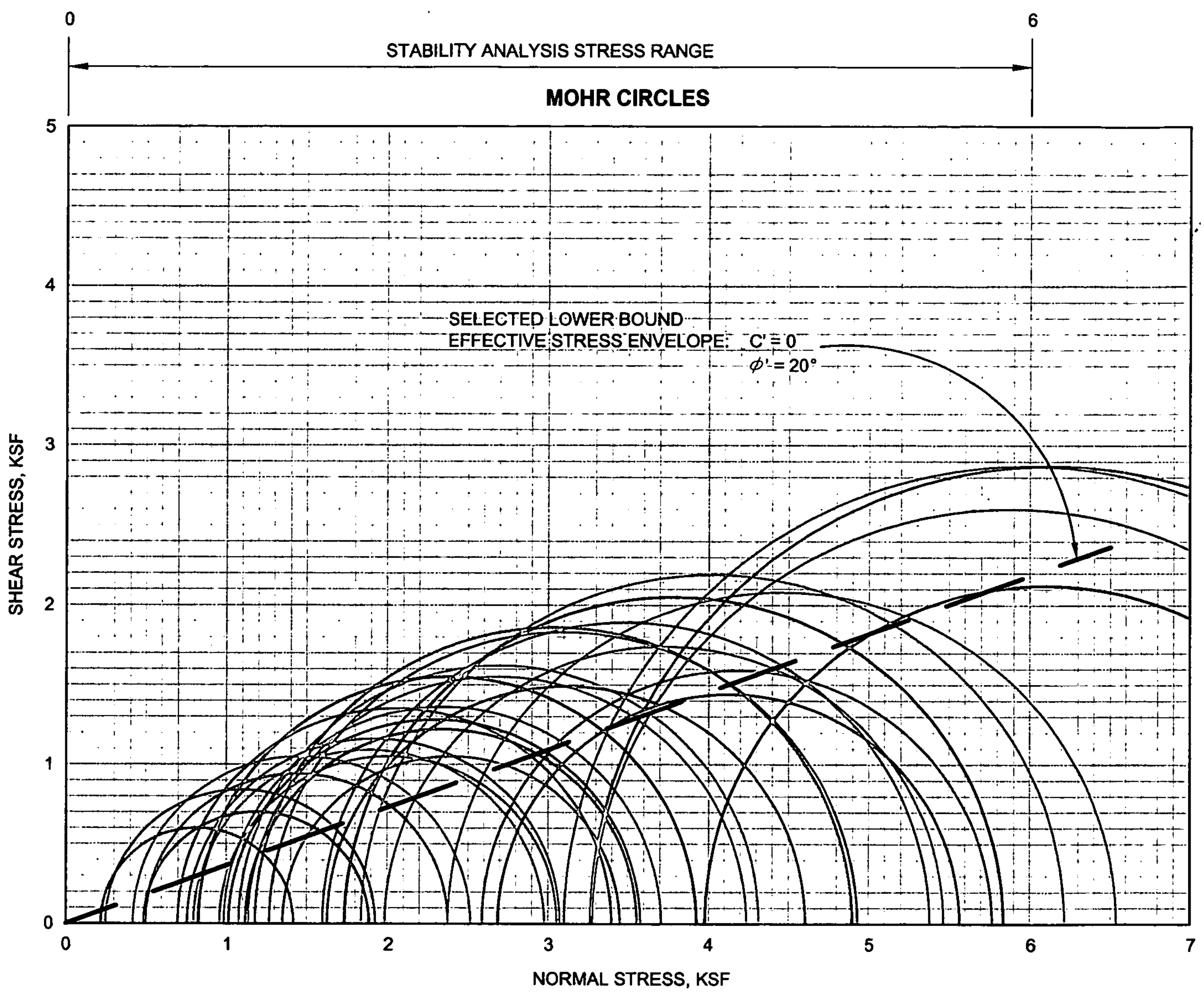
EARTH TECH

FIGURE 2

ORIGINAL LANDFILL GEOTECHNICAL INVESTIGATION
TRIAXIAL SHEAR TEST DATA - DRAINED STRENGTH

ROCKY FLATS ENVIRONMENTAL TECHNOLOGY SITE
GOLDEN, COLORADO

NOVEMBER 2004 57378



ICU TRIAXIAL TEST RESULTS

KEY	MATERIAL[1]	LOCATION	SAMPLE	DEPTH (feet)	USCS[2]	DENSITY (pcf)	DRAINED STRENGTH[3] COHESION (psf)	FRICTION ANGLE (degrees)
——	CSSW	TP1	L1 L2 L3	14 14 14		125 127 125	150	30
——	CSSW	TP4	L1 L2 L3	10 10 10		121 122 127	400	15
——	CSSW	TP6	L1 L2 L3	7 7 7		126 126 130	150	35
——	CSMW	B3	S2	18-20.5	CH	130 129 127	700	16
——	Qc	B4	S2	12-14.5	CH	125 120 122	450	16
——	CSSW	B4	S3	14.5-17	CH	129 125 125	500	22
——	CSSW	B6	S1	11-13.4	CH	123 128 124	600	20
——	CSSW	B7	S1	13-15	CH	128 128 127	400	24
——	Qc	B8	S1	6-8.2		120 121 122	400	28
——	CSMW	B7	L7 L8 L9	17.5-18 18-18.5 18.5-19	CH	122 125 120	500	19

[1] Qc = COLLUVIUM/SLIDE, CSSW = SEVERELY WEATHERED CLAYSTONE, CSMW = MODERATELY WEATHERED CLAYSTONE

[2] UNIFIED SOIL CLASSIFICATION, BASED ON GRADATION AND ATTERBERG LIMITS

[3] BASED ON 5 PERCENT STRAIN FAILURE CRITERIA, EFFECTIVE STRESS PARAMETERS

E A R T H T E C H

FIGURE 3

ORIGINAL LANDFILL GEOTECHNICAL INVESTIGATION
TRIAXIAL SHEAR TEST DATA - DRAINED STRENGTH

ROCKY FLATS ENVIRONMENTAL TECHNOLOGY SITE
GOLDEN, COLORADO

NOVEMBER 2004 57378

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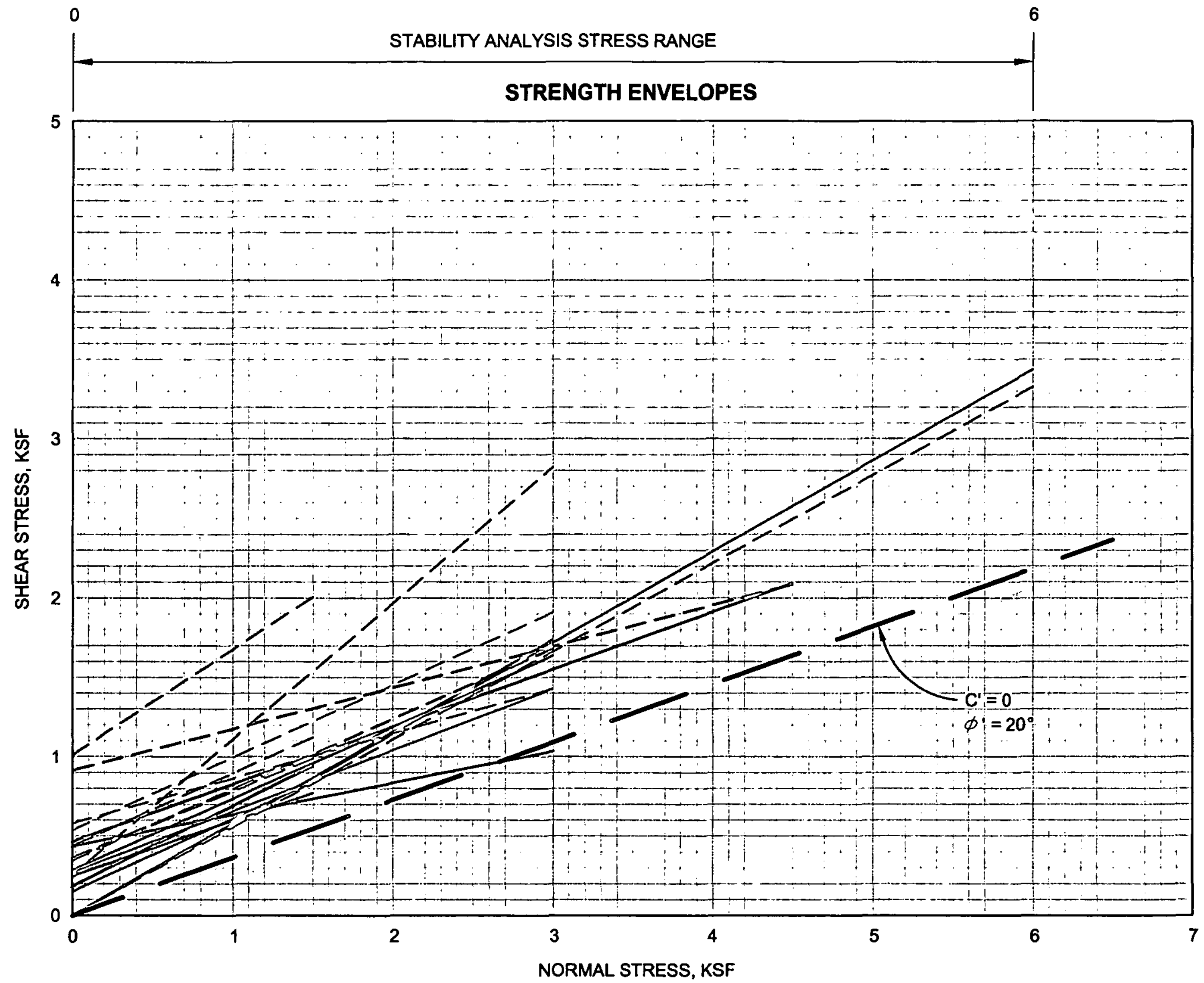
STRENGTH ENVELOPES



DIRECT SHEAR TEST RESULTS [1]

KEY[2]	MATERIAL[3]	LOCATION	SAMPLE	DEPTH (feet)	USCS[4]	DENSITY (pcf)	PEAK STRENGTH[2] COHESION (psf)	PEAK STRENGTH[2] FRICTION ANGLE (degrees)	RESIDUAL STRENGTH[2] COHESION (psf)	RESIDUAL STRENGTH[2] FRICTION ANGLE (degrees)
——	CSSW	TP1	L4	14	CH	124 125 124	535	24.6	0	30.1
——	CSSW	TP4	L4	10	CH	101 118 108	346	24.0	434	11.3
——	CSSW	TP6	L4	7	CH	134 134 131	1008	33.6	245	19.3
——	Qc	B3	L3 L4 L4	15.5-16 16-16.5 16-16.5		126 124 124	912	14.6	463	19.9
——	CSMW	B4	L5 L6 L6	19.5-20 20-20.5 20-20.5	CH	122 126 131	0	29.0	0	24.8
——	Qc	B7	L2 L3 L3	8.5-9 9-9.5 9-9.5	CL	127 125 124	358	22.9	180	26.9
——	CSSW	B7	L4 L5 L6	11.5-12 12-12.5 12.5-13		125 122 122	579	15.8	269	21.1
——	CSSW	B9	L5 L7 L8	7-7.5 8.5-9 9-9.5	CH	123 123 127	435	24.6	149	24.6
——	CSMW	B10	L5 L6 L6	9.5-10 10-10.5 10-10.5	CH	124 124 124	25	40.6	282	24.3

[1] CONSOLIDATED DRAINED PROCEDURES (EFFECTIVE STRESS PARAMETERS)
[2] DASHED = PEAK STRENGTH, SOLID = RESIDUAL STRENGTH
[3] Qc = COLLUVIUM/SLIDE, CSSW = SEVERELY WEATHERED CLAYSTONE, CSMW = MODERATELY WEATHERED CLAYSTONE
[4] UNIFIED SOIL CLASSIFICATION, BASED ON GRADATION AND ATTERBERG LIMITS

EARTH TECH

FIGURE 4
ORIGINAL LANDFILL GEOTECHNICAL INVESTIGATION
DIRECT SHEAR TEST DATA - DRAINED STRENGTH
ROCKY FLATS ENVIRONMENTAL TECHNOLOGY SITE
GOLDEN, COLORADO
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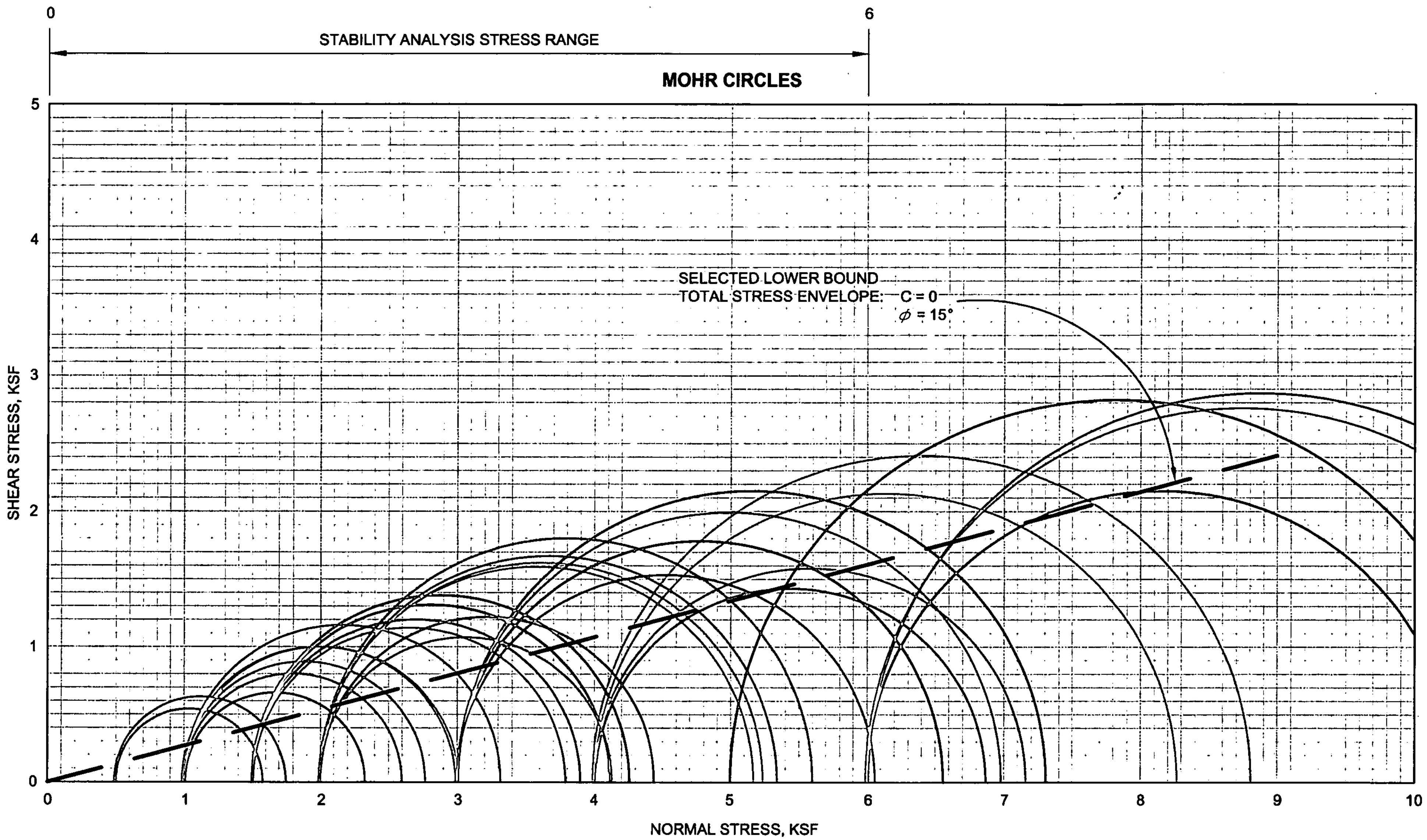

ICU TRIAXIAL TEST RESULTS

KEY	MATERIAL[1]	LOCATION	SAMPLE	DEPTH (feet)	USCS[2]	DENSITY (pcf)	UNDRAINED STRENGTH[3] COHESION (psf)	FRICTION ANGLE (degrees)
——	CSSW	TP1	L1 L2 L3	14 14 14		125 127 125	400	19
——	CSSW	TP4	L1 L2 L3	10 10 10		121 122 127	300	12
——	CSSW	TP6	L1 L2 L3	7 7 7		126 126 130	150	24
——	CSMW	B3	S2	18-20.5	CH	130 129 127	600	13
——	Qc	B4	S2	12-14.5	CH	125 120 122	500	11
——	CSSW	B4	S3	14.5-17	CH	129 125 125	600	15
——	CSSW	B6	S1	11-13.4	CH	123 128 124	450	17
——	CSSW	B7	S1	13-15	CH	128 128 127	300	18
——	Qc	B8	S1	6-8.2		120 121 122	300	24
——	CSMW	B7	L7 L8 L9	17.5-18 18-18.5 18.5-19	CH	122 125 120	600	13

[1] Qc = COLLUVIUM/SLIDE, CSSW = SEVERELY WEATHERED CLAYSTONE, CSMW = MODERATELY WEATHERED CLAYSTONE

[2] UNIFIED SOIL CLASSIFICATION, BASED ON GRADATION AND ATTERBERG LIMITS

[3] BASED ON MAXIMUM PRINCIPAL STRESS RATIO FAILURE CRITERIA, TOTAL STRESS PARAMETERS

EARTH TECH

FIGURE 5

ORIGINAL LANDFILL GEOTECHNICAL INVESTIGATION
TRIAXIAL SHEAR TEST DATA - UNDRAINED STRENGTH

ROCKY FLATS ENVIRONMENTAL TECHNOLOGY SITE
GOLDEN, COLORADO

NOVEMBER 2004 57378

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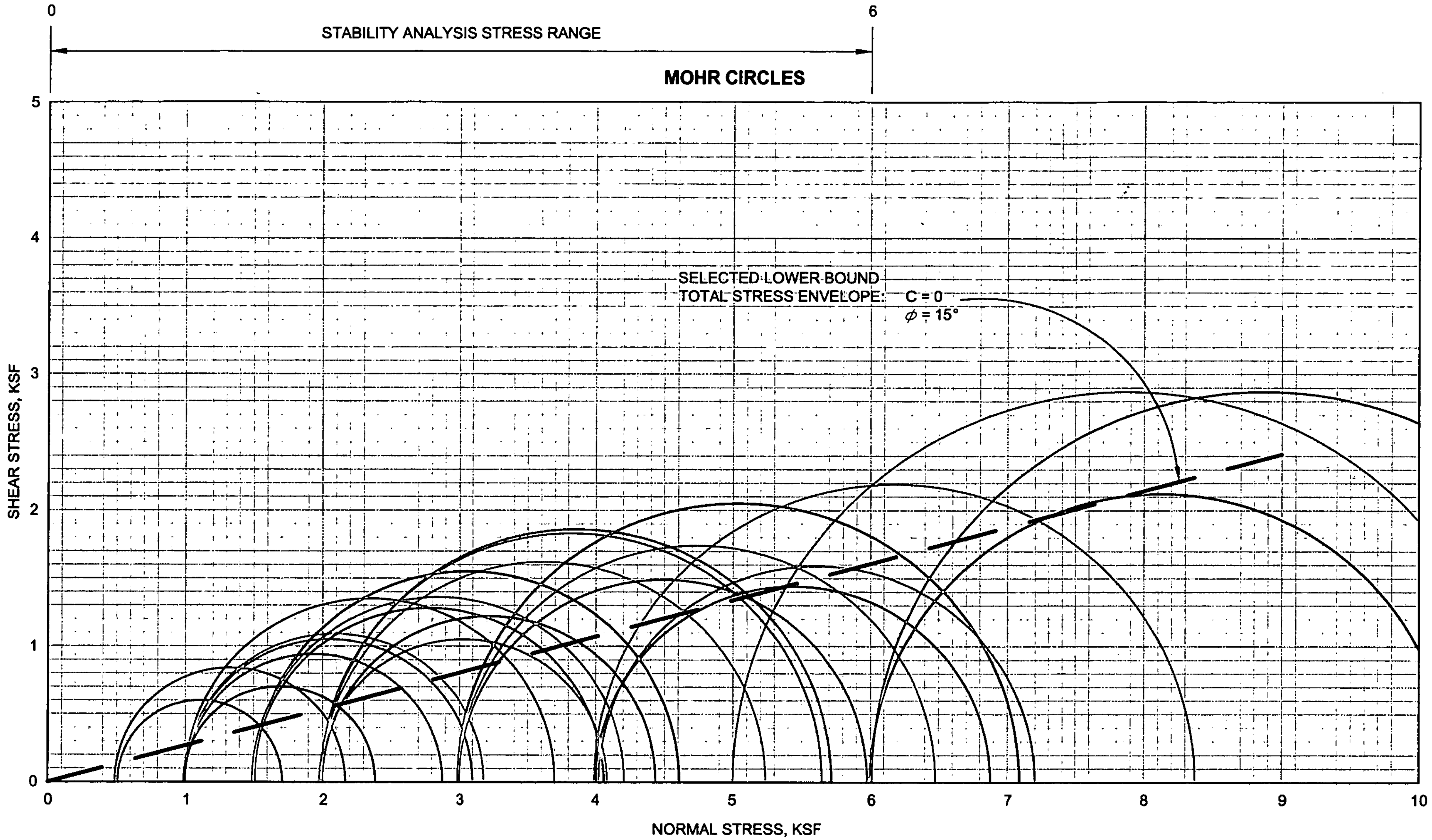

ICU TRIAXIAL TEST RESULTS

KEY	MATERIAL[1]	LOCATION	SAMPLE	DEPTH (feet)	USCS[2]	DENSITY (pcf)	UNDRAINED STRENGTH[3] COHESION (psf)	UNDRAINED STRENGTH[3] FRICTION ANGLE (degrees)
——	CSSW	TP1	L1 L2 L3	14 14 14		125 127 125	550	16
——	CSSW	TP4	L1 L2 L3	10 10 10		121 122 127	400	11
——	CSSW	TP6	L1 L2 L3	7 7 7		126 126 130	100	26
——	CSMW	B3	S2	18-20.5	CH	130 129 127	800	11
——	Qc	B4	S2	12-14.5	CH	125 120 122	600	10
——	CSSW	B4	S3	14.5-17	CH	129 125 125	700	14
	CSSW	B6	S1	11-13.4	CH	123 128 124	500	16
	CSSW	B7	S1	13-15	CH	128 128 127	400	16
——	Qc	B8	S1	6-8.2		120 121 122	350	23
——	CSMW	B7	L7 L8 L9	17.5-18 18-18.5 18.5-19	 CH	122 125 120	700	12

1 Qc = COLLUVIUM/SLIDE, CSSW = SEVERELY WEATHERED CLAYSTONE, CSMW = MODERATELY WEATHERED CLAYSTONE

2 UNIFIED SOIL CLASSIFICATION, BASED ON GRADATION AND ATTERBERG LIMITS

3 BASED ON 5 PERCENT STRAIN FAILURE CRITERIA, TOTAL STRESS PARAMETERS

EARTH TECH

FIGURE 6

ORIGINAL LANDFILL GEOTECHNICAL INVESTIGATION
TRIAXIAL SHEAR TEST DATA - UNDRAINED STRENGTH

ROCKY FLATS ENVIRONMENTAL TECHNOLOGY SITE
GOLDEN, COLORADO

NOVEMBER 2004

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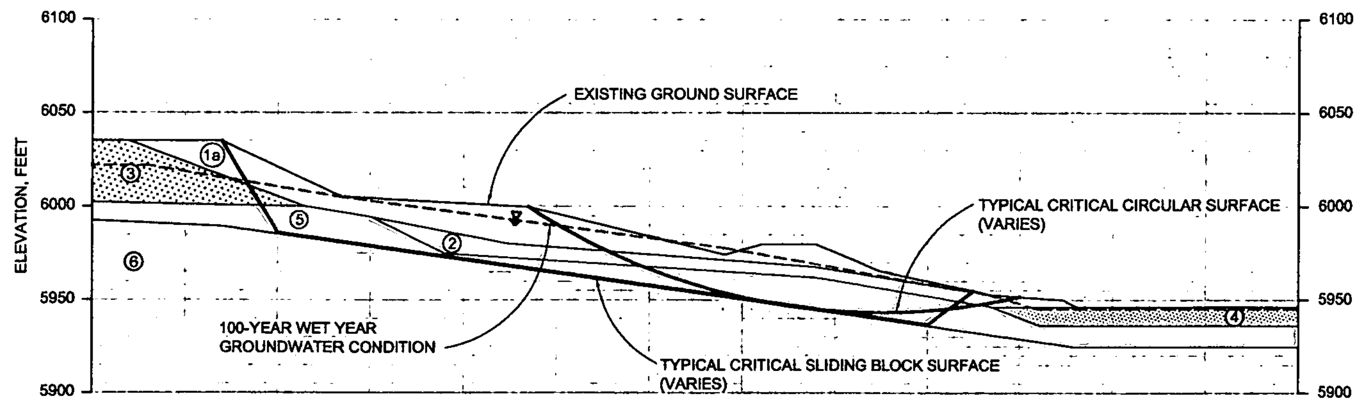
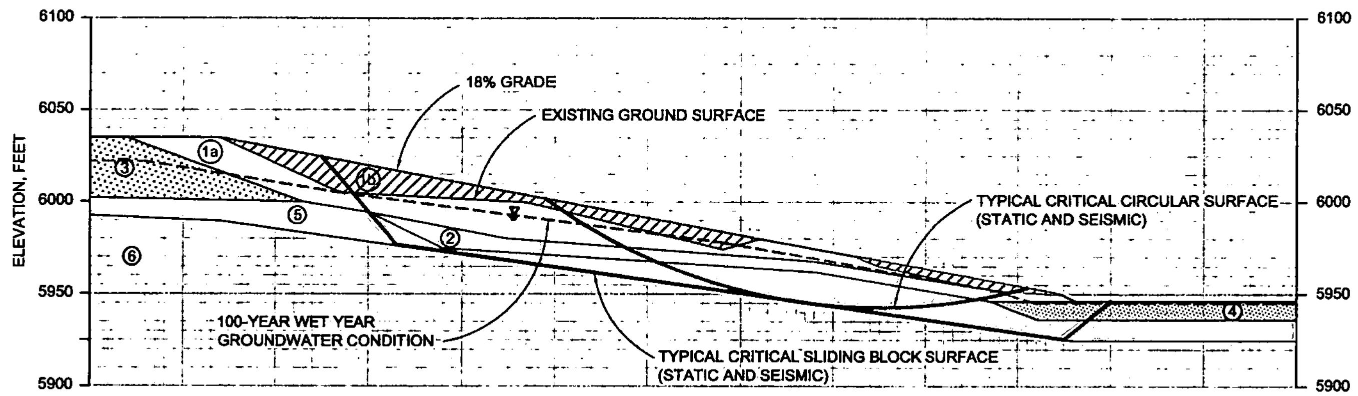
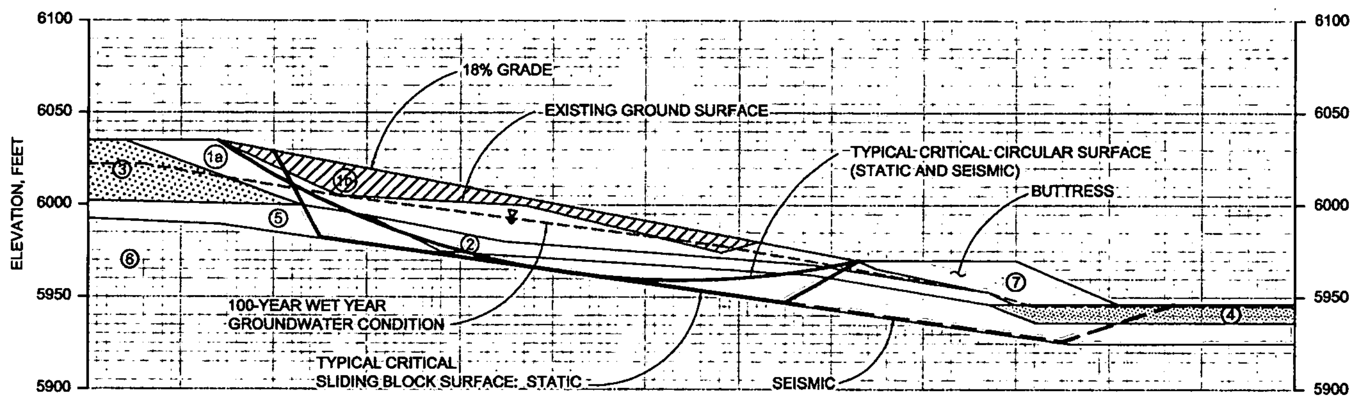


EXISTING CONDITION



18% REGRADE CONDITION



18% REGRADE WITH BUTTRESS CONDITION

STABILITY ANALYSIS SOIL PARAMETERS

KEY	MATERIAL DESIGNATION	DESCRIPTION	UNIT WEIGHT		SHEAR STRENGTH			
					STATIC		SEISMIC	
			MOIST (pcf)	SATURATED (pcf)	COHESION (psf)	FRICTION ANGLE (degrees)	COHESION (psf)	FRICTION ANGLE (degrees)
	1a	WASTE	120	125	50	30	50	30
//////	1b	WASTE / FILL / COVER	120	125	50	30	50	30
	2	COLLUVIUM / SLIDE	120	125	0	20	0	15
	3	ROCKY FLATS ALLUVIUM	120	125	0	37	200	30
	4	STREAM ALLUVIUM	125	130	0	33	0	33
	5	WEATHERED CLAYSTONE	120	125	0	20	0	15
	6	UNWEATHERED CLAYSTONE	125	130	600	30	600	30
	7	ENGINEERED FILL	130	135	200	35	200	35

1995 METCALF & EDDY REPORT SECTION B-B'

0 25 50
SCALE IN FEET

GEOMETRIC CONDITION	ANALYSIS TYPE	GROUNDWATER CONDITION	MINIMUM SAFETY FACTOR		YIELD[3] ACCELERATION	MAXIMUM[4] SEISMIC DISPLACEMENT
			STATIC	0.06 g[2]		
EXISTING	CIRCULAR SEARCH	AVERAGE[1] WET YEAR	1.5	0.8	0.02	10"
		100-YEAR WET YEAR	1.4	0.8	0.01	N/A[5]
	SLIDING BLOCK SEARCH	AVERAGE[1] WET YEAR	1.4	0.8	0.01	N/A[5]
		100-YEAR WET YEAR	1.3	0.8	0.01	N/A[5]
18% REGRADE	CIRCULAR SEARCH	AVERAGE[1] WET YEAR	1.6	0.9	0.03	6"
		100-YEAR WET YEAR	1.5	0.9	0.02	10"
	SLIDING BLOCK SEARCH	AVERAGE[1] WET YEAR	1.6	0.9	0.03	6"
		100-YEAR WET YEAR	1.5	0.9	0.02	10"
18% REGRADE WITH BUTTRESS	CIRCULAR SEARCH	AVERAGE[1] WET YEAR	1.7	1.0	0.06	3"
		100-YEAR WET YEAR	1.7	1.0	0.05	4"
	SLIDING BLOCK SEARCH	AVERAGE[1] WET YEAR	1.7	1.0	0.05	4"
		100-YEAR WET YEAR	1.7	0.9	0.04	5"

[1] AVERAGE WET YEAR GROUNDWATER CONDITION, NOT SHOWN ON SECTIONS, IS 1 TO 2 FEET LOWER THAN 100-YEAR WET YEAR GROUNDWATER CONDITION.

[2] SEISMIC COEFFICIENT FOR PSEUDOSTATIC ANALYSIS.

[3] SEISMIC COEFFICIENT THAT PRODUCES SAFETY FACTOR OF 1.0 IN PSEUDOSTATIC ANALYSIS.

[4] ESTIMATED MAXIMUM SEISMICALLY INDUCED PERMANENT DISPLACEMENT USING SIMPLIFIED DEFORMATION ANALYSIS.

[5] PROCEDURE FOR ESTIMATING SEISMICALLY INDUCED PERMANENT DISPLACEMENT BECOMES INVALID, IN THIS CASE, FOR YIELD ACCELERATIONS OF 0.01 AND LESS. MAXIMUM DISPLACEMENT IN THIS CASE LIKELY GREATER THAN 12 INCHES.

EARTH TECH

FIGURE 7
ORIGINAL LANDFILL GEOTECHNICAL INVESTIGATION
STABILITY ANALYSES - M&E SECTION B-B'
ROCKY FLATS ENVIRONMENTAL TECHNOLOGY SITE
GOLDEN, COLORADO
NOVEMBER 2004
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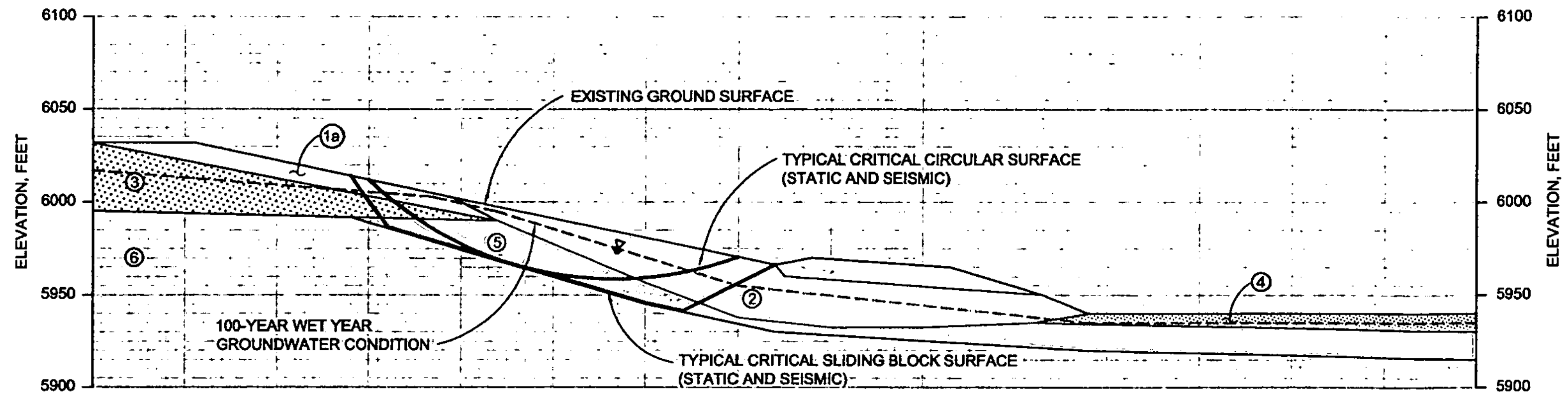
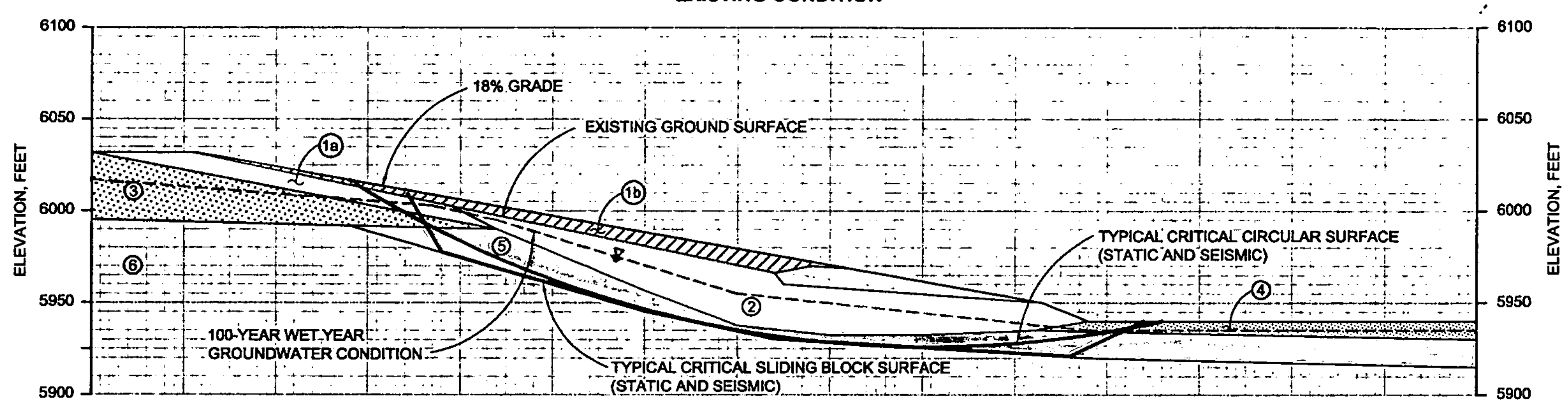
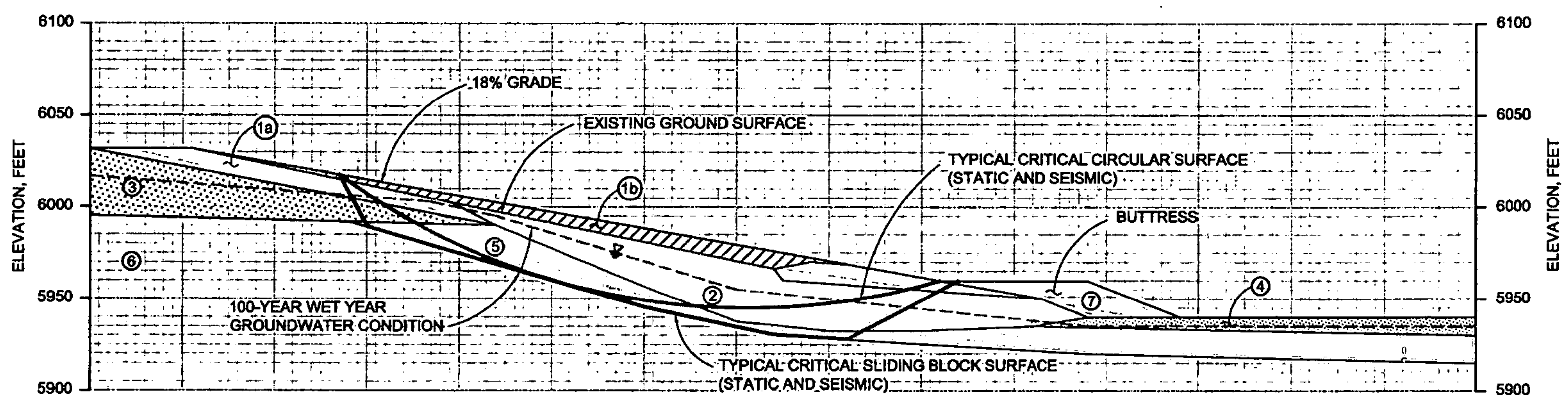


EXISTING CONDITION



18% REGRADE CONDITION



18% REGRADE WITH BUTTRESS CONDITION

STABILITY ANALYSIS SOIL PARAMETERS

KEY	MATERIAL DESIGNATION	DESCRIPTION	UNIT WEIGHT		SHEAR STRENGTH			
					STATIC		SEISMIC	
			MOIST (pcf)	SATURATED (pcf)	COHESION (psf)	FRICTION ANGLE (degrees)	COHESION (psf)	FRICTION ANGLE (degrees)
	1a	WASTE	120	125	50	30	50	30
	1b	WASTE / FILL / COVER	120	125	50	30	50	30
	2	COLLUVIUM / SLIDE	120	125	0	20	0	15
	3	ROCKY FLATS ALLUVIUM	120	125	0	37	200	30
	4	STREAM ALLUVIUM	125	130	0	33	0	33
	5	WEATHERED CLAYSTONE	120	125	0	20	0	15
	6	UNWEATHERED CLAYSTONE	125	130	600	30	600	30
	7	ENGINEERED FILL	130	135	200	35	200	35

1995 METCALF & EDDY REPORT SECTION C-C'

GEOMETRIC CONDITION	ANALYSIS TYPE	GROUNDWATER CONDITION	MINIMUM SAFETY FACTOR		YIELD [3] ACCELERATION	MAXIMUM [4] SEISMIC DISPLACEMENT
			STATIC	0.06 g [2]		
EXISTING	CIRCULAR SEARCH	AVERAGE [1] WET YEAR	1.4	0.8	0.01	N/A [5]
		100-YEAR WET YEAR	1.4	0.8	0.01	N/A [5]
	SLIDING BLOCK SEARCH	AVERAGE [1] WET YEAR	1.5	0.9	0.02	10"
		100-YEAR WET YEAR	1.5	0.8	0.01	N/A [5]
18% REGRADE	CIRCULAR SEARCH	AVERAGE [1] WET YEAR	1.7	0.9	0.04	5"
		100-YEAR WET YEAR	1.6	0.9	0.03	6"
	SLIDING BLOCK SEARCH	AVERAGE [1] WET YEAR	1.7	0.9	0.04	5"
		100-YEAR WET YEAR	1.6	0.9	0.03	6"
18% REGRADE WITH BUTTRESS	CIRCULAR SEARCH	AVERAGE [1] WET YEAR	1.8	1.0	0.06	3"
		100-YEAR WET YEAR	1.8	1.0	0.06	3"
	SLIDING BLOCK SEARCH	AVERAGE [1] WET YEAR	1.9	1.0	0.06	3"
		100-YEAR WET YEAR	1.8	1.0	0.06	3"

[1] AVERAGE WET YEAR GROUNDWATER CONDITION, NOT SHOWN ON SECTIONS, IS 0 TO 2 FEET LOWER THAN 100-YEAR WET YEAR GROUNDWATER CONDITION.

[2] SEISMIC COEFFICIENT FOR PSEUDOSTATIC ANALYSIS.

[3] SEISMIC COEFFICIENT THAT PRODUCES SAFETY FACTOR OF 1.0 IN PSEUDOSTATIC ANALYSIS.

[4] ESTIMATED MAXIMUM SEISMICALLY INDUCED PERMANENT DISPLACEMENT USING SIMPLIFIED DEFORMATION ANALYSIS.

[5] PROCEDURE FOR ESTIMATING SEISMICALLY INDUCED PERMANENT DISPLACEMENT BECOMES INVALID, IN THIS CASE, FOR YIELD ACCELERATIONS OF 0.01 AND LESS. MAXIMUM DISPLACEMENT IN THIS CASE LIKELY GREATER THAN 12 INCHES.

0 25 50
SCALE IN FEET

EARTH TECH

FIGURE 8

ORIGINAL LANDFILL GEOTECHNICAL INVESTIGATION STABILITY ANALYSES - M&E SECTION C-C'

ROCKY FLATS ENVIRONMENTAL TECHNOLOGY SITE
GOLDEN, COLORADO

NOVEMBER 2004 57378

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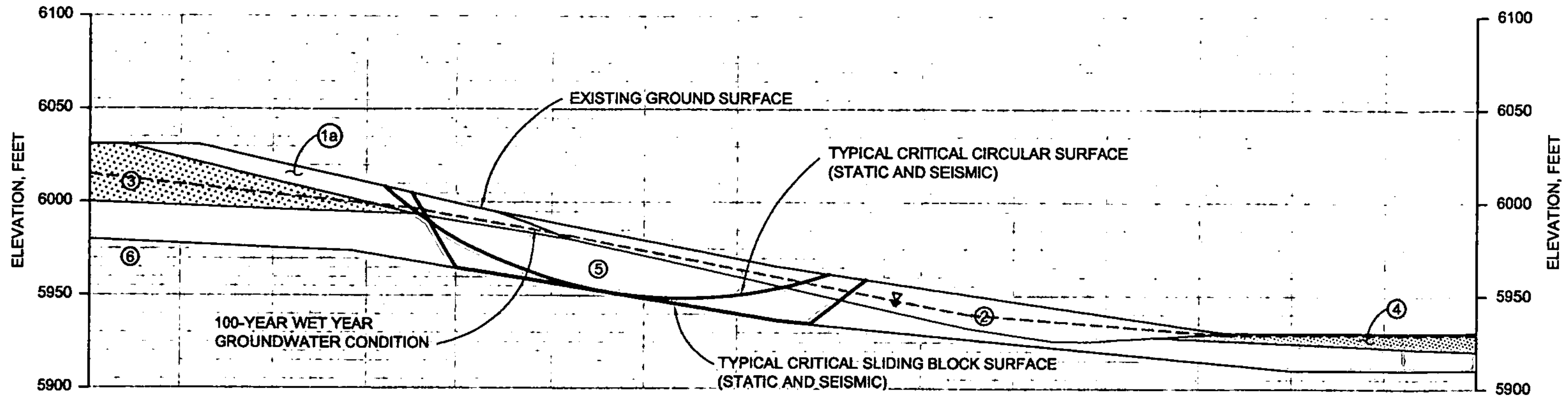
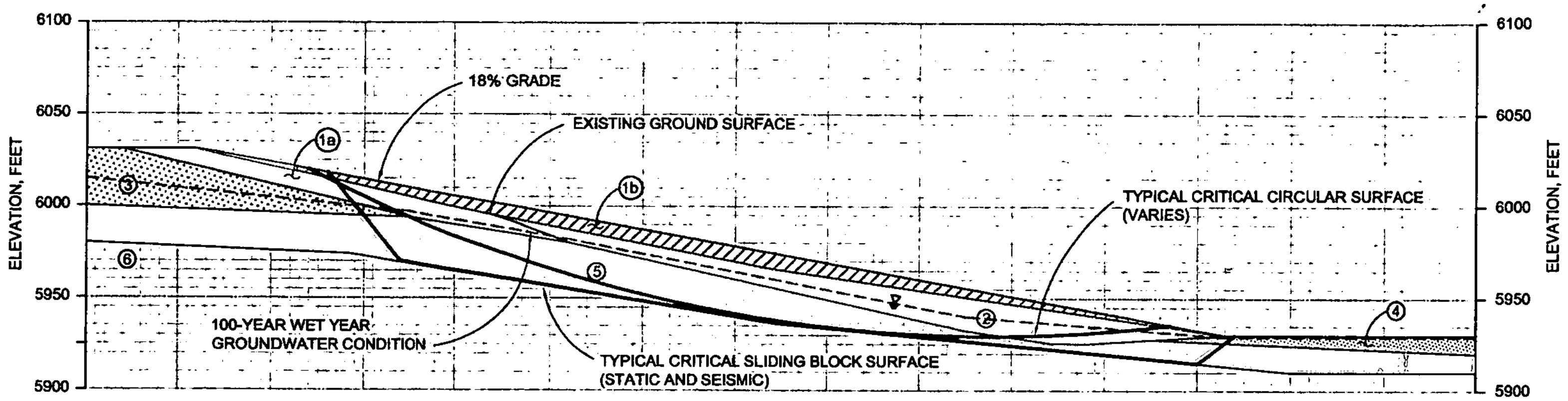
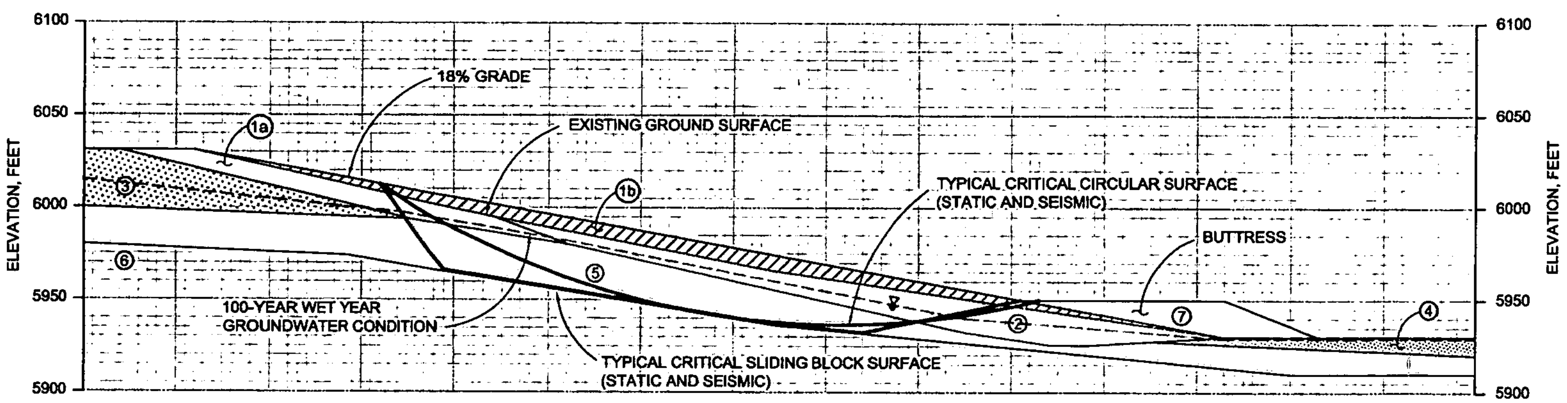


EXISTING CONDITION



18% REGRADE CONDITION



18% REGRADE WITH BUTTRESS CONDITION

STABILITY ANALYSIS SOIL PARAMETERS

KEY	MATERIAL DESIGNATION	DESCRIPTION	UNIT WEIGHT MOIST (pcf)	UNIT WEIGHT SATURATED (pcf)	SHEAR STRENGTH STATIC COHESION (psf)	SHEAR STRENGTH STATIC FRICTION ANGLE (degrees)	SHEAR STRENGTH SEISMIC COHESION (psf)	SHEAR STRENGTH SEISMIC FRICTION ANGLE (degrees)
	1a	WASTE	120	125	50	30	50	30
	1b	WASTE / FILL / COVER	120	125	50	30	50	30
	2	COLLUVIUM / SLIDE	120	125	0	20	0	15
	3	ROCKY FLATS ALLUVIUM	120	125	0	37	200	30
	4	STREAM ALLUVIUM	125	130	0	33	0	33
	5	WEATHERED CLAYSTONE	120	125	0	20	0	15
	6	UNWEATHERED CLAYSTONE	125	130	600	30	600	30
	7	ENGINEERED FILL	130	135	200	35	200	35

1995 METCALF & EDDY REPORT SECTION D-D'

0 25 50
SCALE IN FEET

GEOMETRIC CONDITION	ANALYSIS TYPE	GROUNDWATER CONDITION	MINIMUM SAFETY FACTOR STATIC	MINIMUM SAFETY FACTOR 0.06 g [2]	YIELD [3] ACCELERATION	MAXIMUM [4] SEISMIC DISPLACEMENT
EXISTING	CIRCULAR SEARCH	AVERAGE [1] WET YEAR	1.3	0.7	N/A [5]	N/A [6]
		100-YEAR WET YEAR	1.3	0.7	N/A [5]	N/A [6]
	SLIDING BLOCK SEARCH	AVERAGE [1] WET YEAR	1.5	0.8	0.01	N/A [6]
		100-YEAR WET YEAR	1.4	0.8	0.01	N/A [6]
18% REGRADE	CIRCULAR SEARCH	AVERAGE [1] WET YEAR	1.7	0.9	0.04	5"
		100-YEAR WET YEAR	1.6	0.9	0.03	6"
	SLIDING BLOCK SEARCH	AVERAGE [1] WET YEAR	1.6	0.9	0.03	6"
		100-YEAR WET YEAR	1.6	0.9	0.02	10"
18% REGRADE WITH BUTTRESS	CIRCULAR SEARCH	AVERAGE [1] WET YEAR	1.7	1.0	0.05	4"
		100-YEAR WET YEAR	1.7	0.9	0.04	5"
	SLIDING BLOCK SEARCH	AVERAGE [1] WET YEAR	1.7	0.9	0.04	5"
		100-YEAR WET YEAR	1.7	0.9	0.04	5"

[1] AVERAGE WET YEAR GROUNDWATER CONDITION, NOT SHOWN ON SECTIONS, IS 0 TO 3 FEET LOWER THAN 100-YEAR WET YEAR GROUNDWATER CONDITION.

[2] SEISMIC COEFFICIENT FOR PSEUDOSTATIC ANALYSIS.

[3] SEISMIC COEFFICIENT THAT PRODUCES SAFETY FACTOR OF 1.0 IN PSEUDOSTATIC ANALYSIS.

[4] ESTIMATED MAXIMUM SEISMICALLY INDUCED PERMANENT DISPLACEMENT USING SIMPLIFIED DEFORMATION ANALYSIS.

[5] SAFETY FACTOR LESS THAN 1.0 FOR 0.0 g (STATIC CONDITION), USING ASSIGNED STRENGTH FOR SEISMIC CONDITION.

[6] PROCEDURE FOR ESTIMATING SEISMICALLY INDUCED PERMANENT DISPLACEMENT BECOMES INVALID, IN THIS CASE, FOR YIELD ACCELERATIONS OF 0.01 AND LESS. MAXIMUM DISPLACEMENT IN THIS CASE LIKELY GREATER THAN 12 INCHES.

EARTH TECH

FIGURE 9

ORIGINAL LANDFILL GEOTECHNICAL INVESTIGATION STABILITY ANALYSES - M&E SECTION D-D'

ROCKY FLATS ENVIRONMENTAL TECHNOLOGY SITE
GOLDEN, COLORADO

NOVEMBER 2004

57378

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APPENDIX A

BOREHOLE AND TEST PIT LOGS

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TEST PIT LOGS

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TRENCH NO. TP-1 LOCATION: Rocky Flats Environmental Technology Site, Original Landfill

SHEET 1 OF 1 NOTES:

UNITS			STRUCTURE			
DEPTH	NO.	DESCRIPTION	NO.	STRIKE	DIP	TYPE
0-8.5' 11'-12.5'	1	COLLUVIUM (GW/SM) SANDY SILTY GRAVEL / GRAVELY SILTY SAND; reddish brown 40% fn to med. sand; 40% fn+cse gravel + cobbles; 5.5'-8.5' becomes dk. brn. moist; free water + seeps @ contact w/ CSSW	A	TP1 L1-L4 Liner samples collected @ (A) aligned in E-W, @ 6" below GW+CSSW contact, massive slicks dipping 10°N Liners driven w/slide hammer		
8.5'-11.0'	2	ALLUVIUM? (SC) CLAYEY SAND; dk. brn.; ~60% fn+med. sand; 40% low plast. clay; moist; appears v. dense; tight + undisturbed.		L1 L2 L3 L4		
12.5-14.5'	3	(CSSW) CLAYSTONE; med gray + reddish brown; sev. wthrd.; moist to wet; soft, plastic; numerous massive slickenside sfcs ~ 12x18"; ~50% FeO2 stained, top 6" caliche deposits in veins + nodules top 6" CSSW imbedded w/ cobbles; free water @ top of contact.				

STATION →

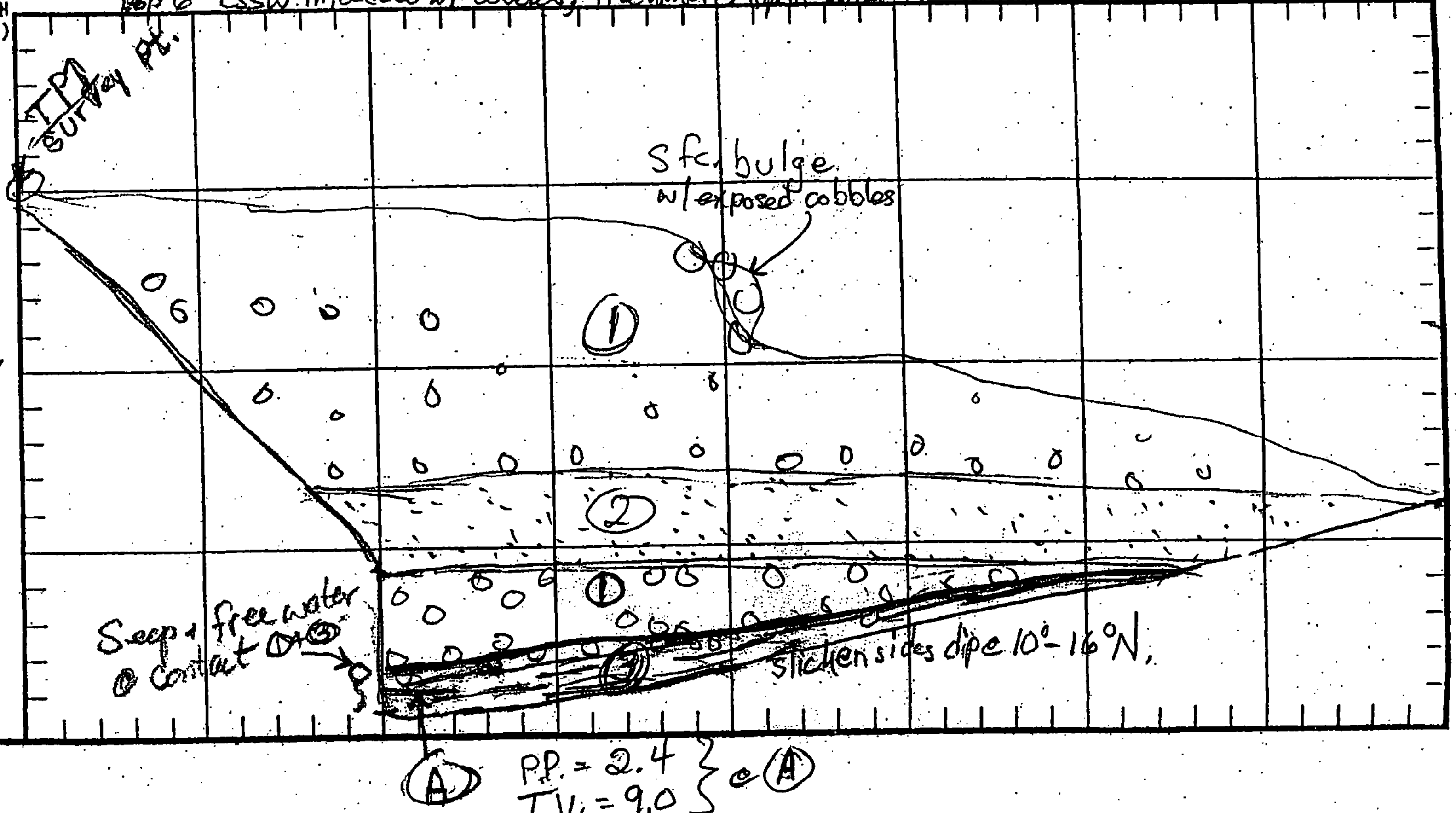
DEPTH (EL.)

6/21/04
DATE

R. Heidrick
LOGGED BY

1" = 5'
SCALE, FT.

N.15°E
BEARING



EARTH TECH
A tyco INTERNATIONAL LTD. COMPANY

GRAPHIC TRENCH LOG

PROJECT NO.	DATE	FIGURE NO.
57378		

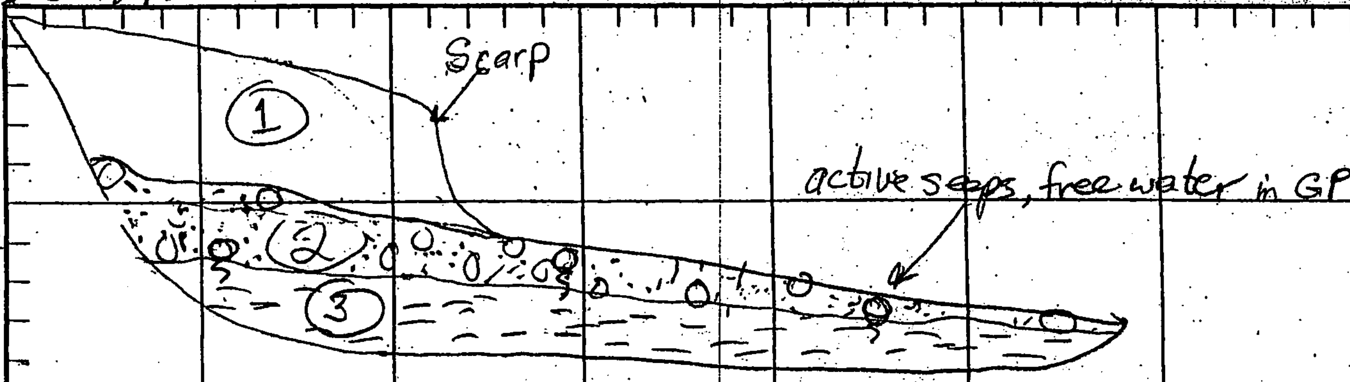
TRENCH NO. TP-2 LOCATION: Rocky Flats Environmental Technology Site, Original Landfill

SHEET 1 OF 1 NOTES:

UNITS			STRUCTURE			
DEPTH	NO.	DESCRIPTION COLLUVIUM	NO:	STRIKE	DIP	TYPE
0'-4'	1	Qc (CL) SANDY CLAY w/ GRAVEL; dk. brn; 60% med. plstc clay; ~25% fn. sand; 15% fn. gravel moist. VALLEY FILL ALLUVIUM	No	Samples	Collected	
4'-6.5'	2	Qal (GW) SANDY GRAVEL; med. brn.; 60% fn. to csa gravel, cobbles + boulders to 2'; 40% csa grained sand; wet, active seeps. BEDROCK				
6.5'-9'	3	CSSW (CL) CLAYSTONE; med. gray; sev. wthrd.; soft; plstc. wthrd to soil; moist; med plsty mottled w/ FeO2, carbon, + caliche; absence of slide plane or zone.				

STATION →

DEPTH (EL.)



6/24/04
DATE

R. Heidrick
LOGGED BY

1" 5'
SCALE, FT.

N. 10°E
BEARING

EARTH TECH
A tyco INTERNATIONAL LTD. COMPANY

GRAPHIC TRENCH LOG

PROJECT NO.	DATE	FIGURE NO.
57378		

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EARTH TECH
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GRAPHIC TRENCH LOG

PROJECT NO. 57378

DATE

FIGURE NO.

TRENCH NO. TP-3 LOCATION: Rocky Flats Environmental Technology Site, Original Landfill

SHEET 1 OF 1 NOTES:

UNITS			STRUCTURE			
DEPTH	NO.	DESCRIPTION	NO:	STRIKE	DIP	TYPE
0-1'	1	Organic layer with reddish clay mixed with cobbles	SAMPLING			
1-3'	2	Colluvium Sandy clay with gravel and intermixed claystone chunks,	L1 —1.2'— L2 —5'— L3 —1.4'— L4			
3-8'	3	CSSW claystone; severly weathered zone; crushed and brecciated; (SSSW?) heavily FeO_2 stains on cleavage surfaces	Sleeves spaced to prevent disturbance while driving samples.			
8-11'	3a	CSMW claystone; moderately weathered; larger cleaves with (SSMW?) heavy FeO_2 stains.				

STATION →

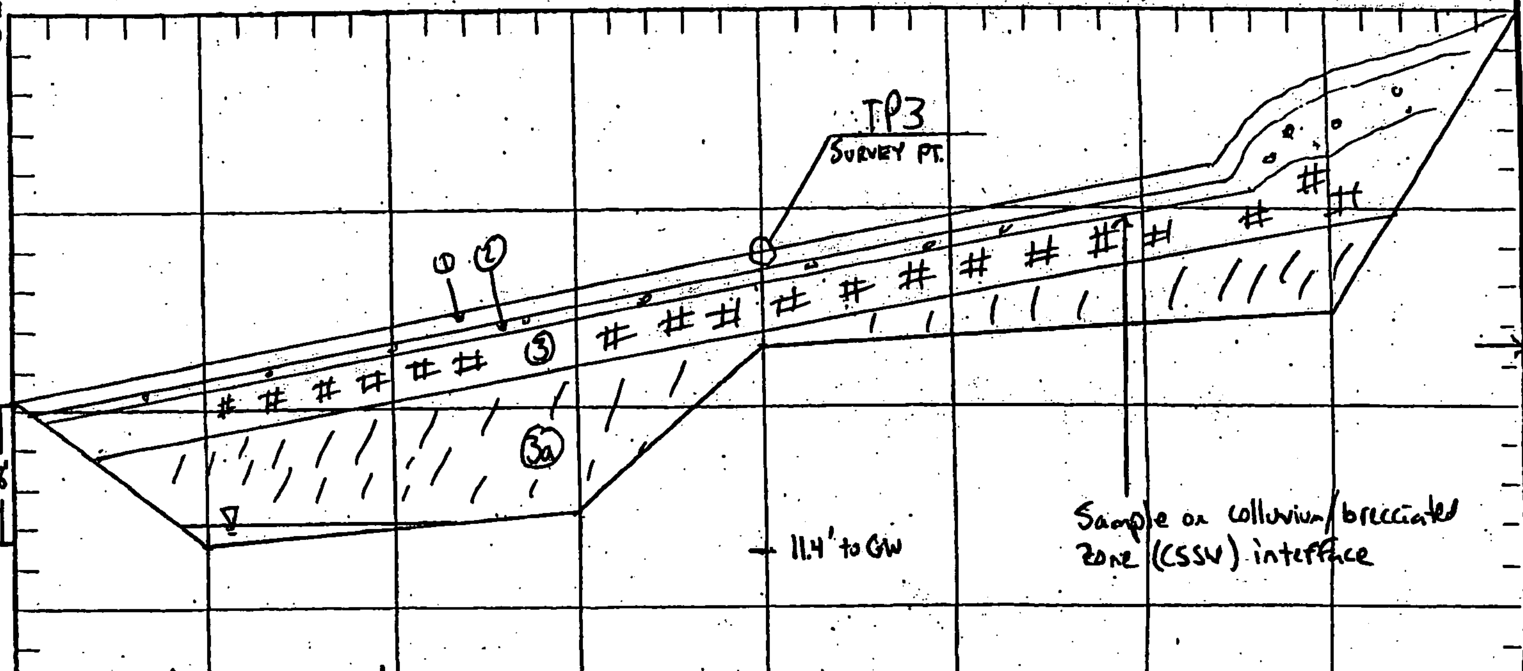
6/25/04
DATE

R. Archibald
LOGGED BY

SCALE, FT. 1" = 10'

N 20° W
BEARING

DEPTH (EL.)



TEST PIT LENGTH: 80'
Souther 40' excavated and did not appear to be a slide area so northern 40' excavated.

TRENCH NO. TP-4 LOCATION: Rocky Flats Environmental Technology Site, Original Landfill
SHEET 1 OF 1 NOTES:

UNITS			STRUCTURE			
DEPTH	NO.	DESCRIPTION	NO.	STRIKE	DIP	TYPE
0'-6'	1	Qc (CL) SANDY CLAY; mod. brn.; damp; 50% mod. plstc. clay; 30% fn. to med. sand; 20% fine + cse gravel occ. cobbles rounded, randomly oriented in CL matrix.	A	E.W.	53° S.	slicks
6'-10'	2	CSMW (SW?) CLAYSTONE; Mod (sev.?) wthrd.; soft, friable; damp; minor deposits of caliche, FeO2, + carbon/charcoal; numerous slks. dip from 53°S to 9°N.	B	E.W.	6° S.	slicks
10'-11'	2a	CSSW CLAYSTONE; sev. wthrd zone; crushed + brecciated; heavy FeO2 stains on cleavage sfcs; massive slks. overlie brecc. zone; damp	C	Slide plane frac'd slightly while driving liners but not across any.		L1 L2 L3 L4

STATION → TP-4 Survey Pt.

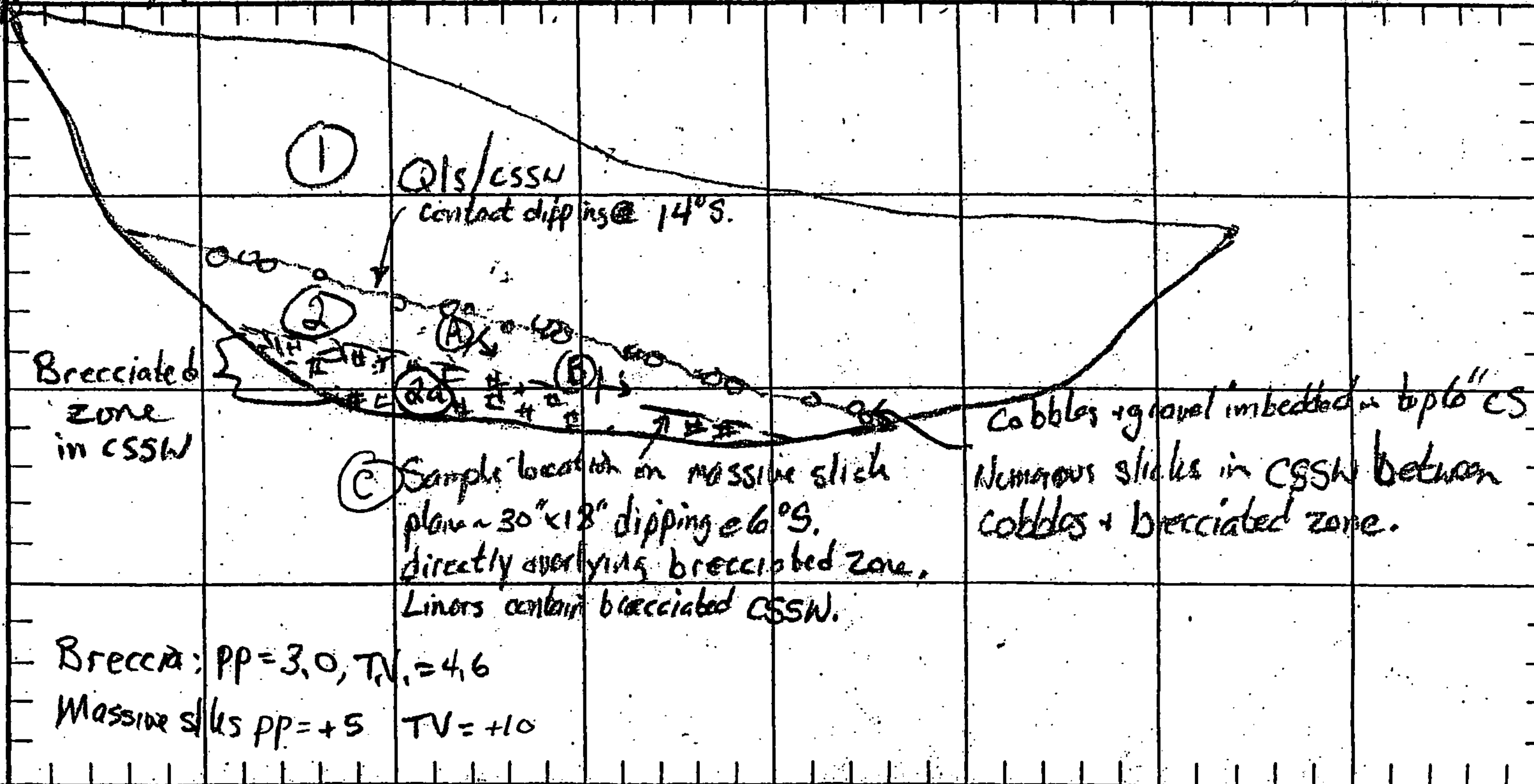
DEPTH (EL.)

6/22/04
DATE

R. Heidrick
LOGGED BY

1" 5'
SCALE, FT.

N5W
BEARING



EARTH TECH
A tyco INTERNATIONAL LTD. COMPANY

GRAPHIC TRENCH LOG

PROJECT NO.	DATE	FIGURE NO.
57378		

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8/8

TRENCH NO. TP-5 LOCATION: Rocky Flats Environmental Technology Site, Original Landfill

SHEET 1 OF 1 NOTES:

UNITS			STRUCTURE			
DEPTH	NO.	DESCRIPTION	NO:	STRIKE	DIP	TYPE
0'-15'	1	QC (CSSU?) SANDY CLAY: med. brn.; 60% med. plstc clay; 25% fn. sand; 15% rounded gravel to 1" randomly dispersed in clay matrix. Randomly mottled w/ orange FeO2, wt. caliche nodules, + black carbon nodules. No structure or orientation or slimy slide planes. VALLEY FILL ... ALLUVIUM		No Sample collected		
15'-21'	2	Qal SANDY GRAVEL W/ COBBLES; med/brn.; rounded gravel to 3" cobbles + boulders to 3'; ~ 30% csc. sand; appears loose.	CS	not encountered		

STATION →

DEPTH (EL.)

6/22/04
DATE

57378
PROJECT NO.

R. Heidrich
LOGGED BY

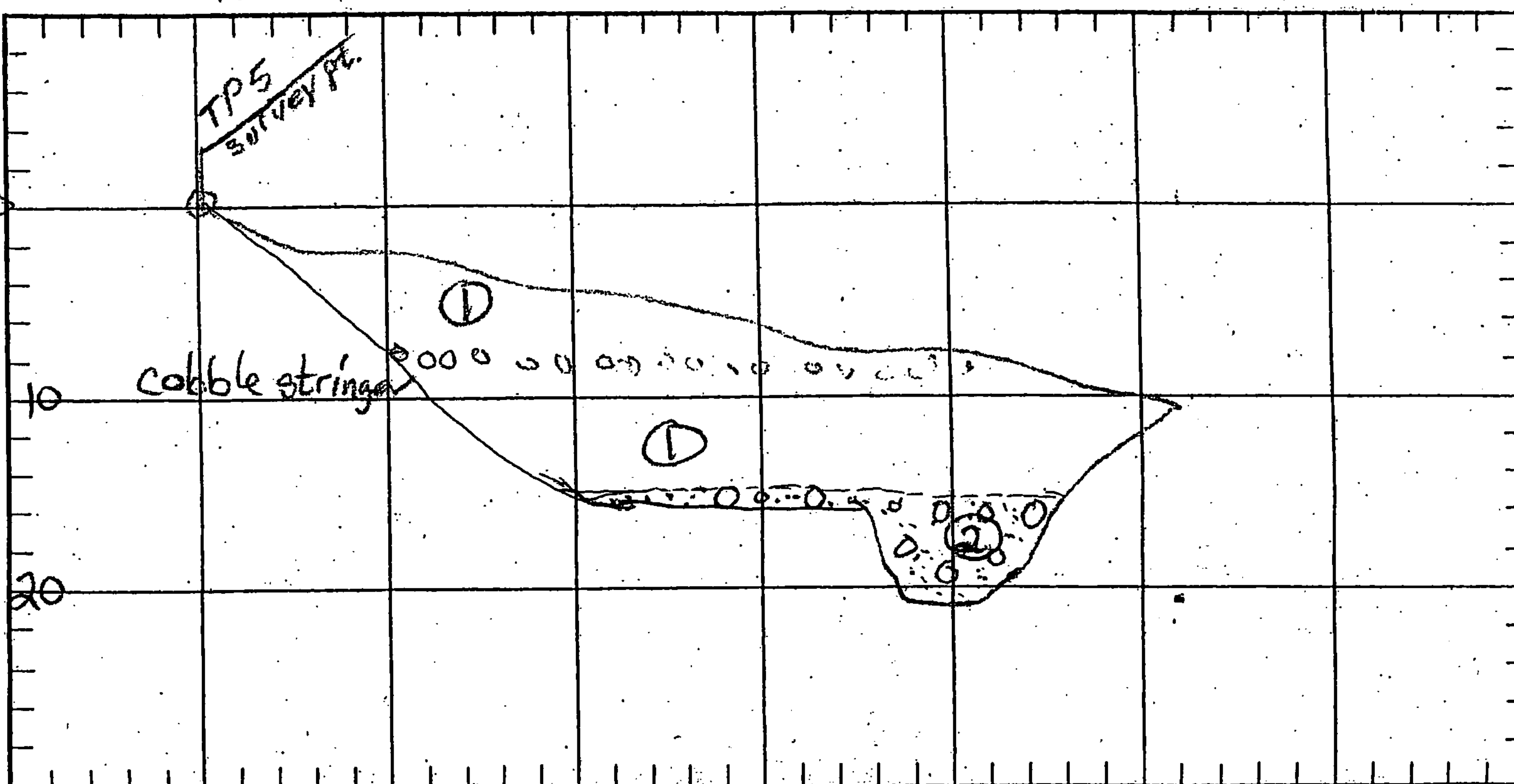
1" 10'
SCALE, FT.

N.5°W
BEARING

GRAPHIC TRENCH LOG

DATE

FIGURE NO.



EARTH TECH
A tyco INTERNATIONAL LTD. COMPANY

TRENCH NO. TP-6 LOCATION: Rocky Flats Environmental Technology Site Original Landfill
SHEET 1 OF 1 NOTES:

UNITS			STRUCTURE			
DEPTH	NO.	DESCRIPTION	NO.	STRIKE	DIP	TYPE
0'-5'	1	Qls / Qc CL / SANDY CLAY w/ GRAVEL; dark brown; ~50% high plstc clay; ~25% fine to cse. gravel w/ cobbles; ~25% sand; appears med. dense; moist; contains chunks of sev. wthrd. claystone (CSSW) and silty sand/sandy silt (SM/ML) incorporated in CL/Qls.	A	N.	~45° W	Shear Zone
5'-6'	2 SC	CLAYEY SAND w/ GRAVEL; reddish brn.; 50% fn to cse. sand; 30% gravel + cobbles; 20% clay; appears med. dense; moist; heavily FeOx stained; permiable; water conduit into CSSW.	B	TP6-L1 location Samples W. to E. L1	thru L4 in middle of collected in along bench L2 L3	Sample shear zone line from e 7' deep L4

STATION →

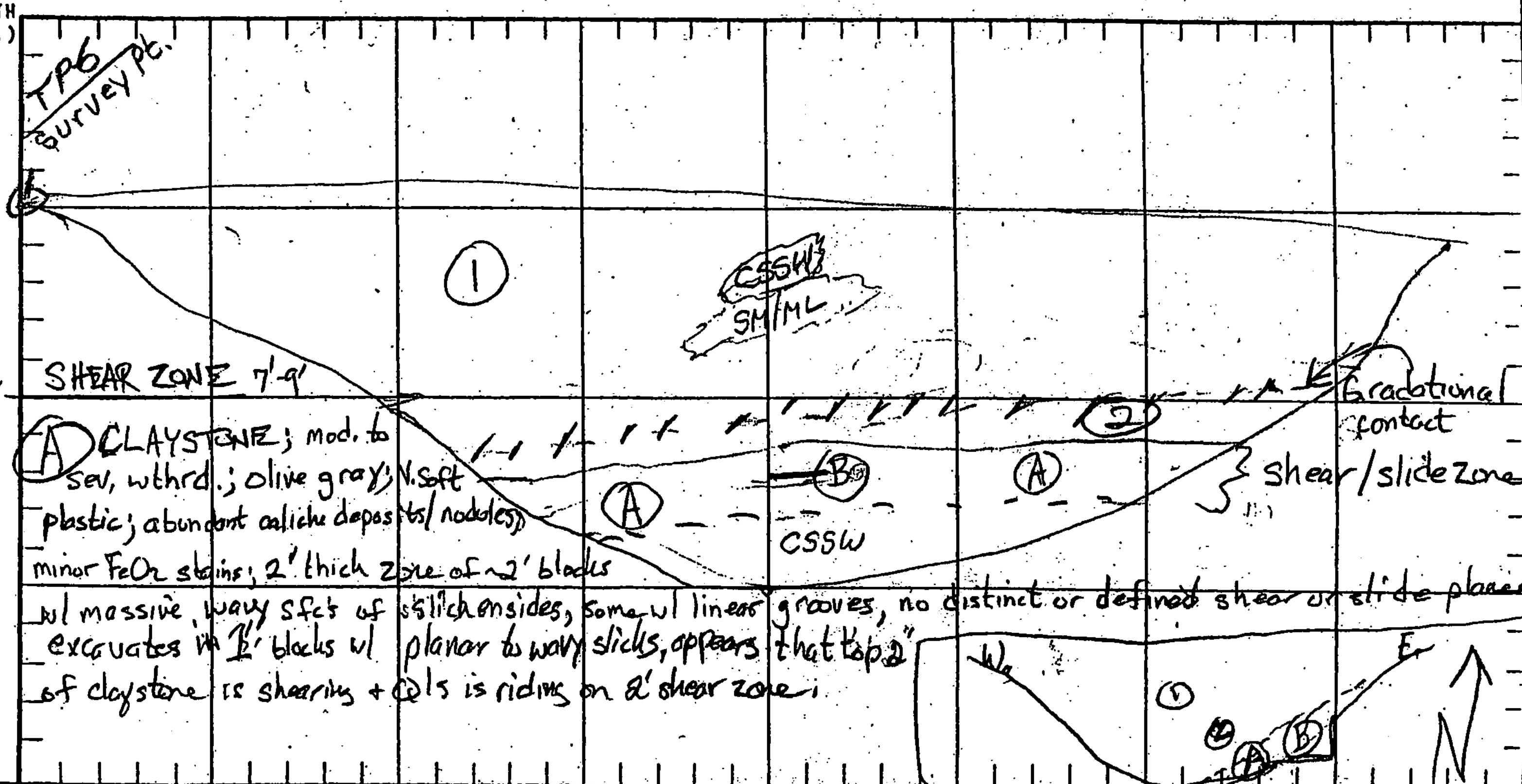
6/18/04
DATE

R. Heidrick
LOGGED BY

1" 5'
SCALE, FT.

N20°W
BEARING

DEPTH (EL.)



A CLAYSTONE; mod. to sev. wthrd.; olive gray; v. soft plastic; abundant caliche deposits/nodules; minor FeOx stains; 2' thick zone of ~2' blocks w/ massive, wavy sfc's of slickensides, some w/ linear grooves, no distinct or defined shear or slide planes, excavates in 1' blocks w/ planar to wavy slicks, appears that top 2" of claystone is shearing + Qls is riding on 2' shear zone.

EARTH TECH
A tyco INTERNATIONAL LTD. COMPANY

GRAPHIC TRENCH LOG

PROJECT NO.	DATE	FIGURE NO.
57378	6/18/04	

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BOREHOLE LOGS

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U.S. DEPARTMENT OF ENERGY ROCKY FLATS PLANT

FORM PRO.101A

PAGE 1 OF 2

ROCKY FLATS ENVIRONMENTAL TECHNOLOGY SITE BOREHOLE LOG

Borehole Number: B1
Location - North: / East:
Date: 6/30/04
Geologist: Rich Heidrick
Drilling Equip.:

Surface Elevation: ~6010
Area: Road
Total Depth: 38.0'
Company:
Sample Type:
Project No.: 57378

RMRS LOGGING SUPERVISOR APPROVAL

DATE

TOP/BOTTOM OF CORE IN BOX	TOP/BOTTOM OF INTERVAL	FEET OF CORE IN INTERVAL (FIELD MEASUREMENT)	SAMPLE NUMBER	FRACTURE ANGLE	BEDDING ANGLE	GRAIN SIZE DISTRIBUTION	USCS SYMBOL	DEPTH IN FEET	SOIL/LITHOLOGIC LOG	SAMPLE DESCRIPTION
							Qf			Road Fill / Fill
X-1	Run 1	2.6'/3.0	C-1				GC	1, 2, 3		0-3.5' CLAYEY GRAVEL: med. brn.; 75% angular gravel + cobbles (crushed rock) to 6"; 25% med. plstc clay (logged from cuttings) moist. (GC) 1.5'-3.5' less cobbles; pred fn + cse gravel; damp; reddish brn.
	Run 2	4.5'/5.0'					SC	4, 5		3.5'-5.0' CLAYEY SAND: lt. yellowish brn.; 80% fn + med sand; 20% low plstc clay; dry; med. dense (SC)
X-2							SP/SM	6, 7, 8		5.0'-15.7' POORLY GRADED SAND / SILTY SAND: orange + white; 90% fine + med. sand; 10% silt; dry; pockets of FeO2, no bedding; imported fill; occ. fat clay. (SP/SM)
	Run 3	2.0'/2.0'						9, 10		10.0'-10.5' FAT CLAY; olive gray; med to high plsty; moist; piece of CS in fill.
X-3	Run 4	2.0'/2.0'						11, 12		10.5'-15.5' wt. sand (SP); med. dense, damp.
X-3	DR	1.5'/1.5'		6 14 18				13		
X-4	DR	1.5'/1.5'		12 12 11				14, 15		BEDROCK
	DR	1.3'/1.5'	L1 L2 L3	5 10 10			CSSW	16		15.7-16.5' CLAYSTONE: sev. wthrd; pred. orange, some gray mottling; v. soft; plstc.; faint relict bedding; heavily FeO2 stained in matrix; PP=3.3
	P	2.3'/2.4'	S-1	250-500 psi			CSMW	17, 18, 19		16.5'-31' CLAYSTONE: mod. wthrd.; dk gray + orange; soft; friable to weak; mod FeO2 staining along bedding planes; PP=5+; distinct bedding thinly laminated; FeO2 on some bed sfc: intact.
X-5	Run 5	4.0'/4.0	C-1					20		

NOTES: General: USCS is modified for this log as follows: locally mod. intensely with; Procedure No. RMRS/OPS-PRO.101
Materials amounts are estimated by % volume instead of % weight. in wet zones, 21'-26' (over). Revision 0
(1) Badly broken core, accurate footage measurements not possible. Date effective: 12/31/98
(2) Core breaks cannot be matched, accurate footage measurements not possible. Page 27 of 28

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(4011-930-0134-930) Form GT.1A(03/01/92)

CSSW removed by grading / excavation activities?

U.S. DEPARTMENT OF ENERGY ROCKY FLATS PLANT

FORM PRO.101A

ROCKY FLATS ENVIRONMENTAL TECHNOLOGY SITE BOREHOLE LOG

PAGE 2 OF 2

Borehole Number: B1

Location - North: ________ East: ________

Date: ________

Geologist: ________

Drilling Equip.: ________

Surface Elevation: ________

Area: ________

Total Depth: ________

Company: ________

Project No.: 57378

Sample Type: ________

RMRS LOGGING SUPERVISOR APPROVAL ________

water e 21.9' on 7/14

DATE ________

interbedded/faulted w/sandstone@29.5'

TOP/BOTTOM OF CORE IN BOX	TOP/BOTTOM OF INTERVAL	FEET OF CORE IN INTERVAL (FIELD MEASUREMENT)	SAMPLE NUMBER	FRACTURE ANGLE	BEDDING ANGLE	GRAIN SIZE DISTRIBUTION	USCS SYMBOL	DEPTH IN FEET	SOIL LITHOLOGIC LOG	SAMPLE DESCRIPTION
X-5	Run 5	4.0' / 4.0'	C-1				CSMW			black (manganese) deposits on bedding sfc's.
								21		21'-22' brecciated + FeO_2 stained.
								22		22' planar bedding e 20°:
X-6								23		23.1'-23.7' 0-45° frac's, wide to 3/4"
	Run 6	4.7' / 5.0'						24		infilled w/ manganese + carbon,
								25		FeO_2 filled, planar to irregular. wet zone.
								26		28'-26' intensely to closely frac'd. smooth frac sfc.
								27		25.5'-26.5' high angle frac, FeO_2 stained
								28		26.5'-29.5'; CS slightly. wthrd.
X-7	Run 7	5.0' / 5.0'						29		
								30	GS	29.5'-31' SANDY SILTSTONE: lt. yellowish brn.;
							CSUW	31	CSUW	modr wthrd.; soft; weak; moist; thinly laminated beds diping 80°; FeO_2 stained parallel bedding
								32		bedding SS interbedded w/ clayey sand; not sheare
								33		31'-38' CLAYSTONE; unweathered;
X-6	Run 8	5.0' / 5.0						34		dk gray; soft; weak mod. strong; closely frac'd:
								35		31.5' frac, 15°, healed, no infilling planar; smooth sfc, in claystone
								36		31.5'-32' brecciated CS
								37		locally crushed; no FeO_2 stains; occ. frac's 55°-70°; sub horz. bedding thinly lamin.
								38		34.5'-36': crushed;
								39		Bott e 1430 GW e 32' e 1450
								40		Backfilled to sfc. w/ bentonite chips

NOTES: General: USCS is modified for this log as follows:
Materials amounts are estimated by % volume instead of % weight.
(1) Badly broken core, accurate footage measurements not possible.
(2) Core breaks cannot be matched, accurate footage measurements not possible.

Procedure No. RMRS/OPS-PRO.101
Revision 0
Date effective: 12/31/98

U.S. DEPARTMENT OF ENERGY ROCKY FLATS PLANT — FORM PRO.101A

U-10 B2a 0' B2

ROCKY FLATS ENVIRONMENTAL TECHNOLOGY SITE BOREHOLE LOG

Borehole Number: B2
Location - North: ______ East: ______
Date: 7/6 + 7/7
Geologist: Rick Heidrich
Drilling Equip.: All terrain CME-75

Surface Elevation: ______
Area: ______
Total Depth: 25.0'
Company: ______
Project No.: 57378
Sample Type: ______

RMRS LOGGING SUPERVISOR APPROVAL ______ DATE Dry to 15' 7/14

TOP/BOTTOM OF CORE IN BOX	TOP/BOTTOM OF INTERVAL	FEET OF CORE IN INTERVAL (FIELD MEASUREMENT)	SAMPLE NUMBER	FRACTURE ANGLE	BEDDING ANGLE	GRAIN SIZE DISTRIBUTION	USCS SYMBOL	DEPTH IN FEET	SOIL LITHOLOGIC LOG	SAMPLE DESCRIPTION FILL
X-1a	Run 1	4.5'/5.0'	C-1				Qf	1		0'-6.5' (CL) SANDY CLAY w/ GRAVEL: med. brn., some orange; 60% med plstc clay; 25% fn. sand; 15% fn + cse gravel to 4"; moist; stiff, 3' PP=5+ 5' PP=2.7
								2–5		
	DR	1.0'/1.5'	L1 L2	6 6 6				6		BEDROCK
X-2a	Run 2	3.5'/5.0'	C1		P 2.3/2.4	S-1	CSSW / CSMW	7–9		6.5'-8' CLAYSTONE; orange; sev. wthrd; to soil; v. soft; plastic; no bedding soil-like; med. plsty; 10% fn sand FeO2 stained throughout
X-3	Run 3				P 2.4'/2.4'	S-2		10–11		8'-17.5' CLAYSTONE: med. gray; mod. wthrd. localized FeO2 stains; soft; friable; thinly laminated; near horizontal, 20°; caliche nodules; v. stiff PP=3.6 carbonaceous; crushed - intensely frac'd.; some FeO2 on frac. sfcs.; vert fracs.
X-4	DR	1.3'/1.5	L3 L4 L5	6 14 24	C 3'/3'			12–13		
	Run 4	1.5'/1.5'	C-1					14–15		
	Run 5	5.0'/5.0'	C-1					16–17		17.5'-25.0' CLAYSTONE; v. dk. gray; unwthrd soft to mod. hard; weak to strong; dry; no FeO2 stains.
X-5							CSUW	18–20		

NOTES: General: USCS is modified for this log as follows:
Materials amounts are estimated by % volume instead of % weight.
(1) Badly broken core, accurate footage measurements not possible.
(2) Core breaks cannot be matched, accurate footage measurements not possible.

Procedure No. RMRS/OPS-PRO.101
Revision 0
Date effective: 12/31/98

(4011-930-0134-930)(Form GT.1A)(03/01/97)

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U.S. DEPARTMENT OF ENERGY ROCKY FLATS PLANT FORM PRO.101A

ROCKY FLATS ENVIRONMENTAL TECHNOLOGY SITE BOREHOLE LOG

PAGE 2 OF 2

Borehole Number: B2
Location - North: ______ East: ______
Date: ______
Geologist: ______
Drilling Equip.: ______

Surface Elevation: ______
Area: ______
Total Depth: ______
Company: ______ Project No.: 57378
Sample Type: ______

RMRS LOGGING SUPERVISOR
APPROVAL ______ DATE ______

TOP/BOTTOM OF CORE IN BOX	TOP/BOTTOM OF INTERVAL	FEET OF CORE IN INTERVAL (FIELD MEASUREMENT)	SAMPLE NUMBER	FRACTURE ANGLE	BEDDING ANGLE	GRAIN SIZE DISTRIBUTION	USCS SYMBOL	DEPTH IN FEET	SOIL LITHOLOGIC LOG	SAMPLE DESCRIPTION
X-5	Run 6	5.0/5.0	C-1						CSUW	CLAYSTONE (cont,)
								21		
								22		
X-6								23		
								24		
								25		
								26		Backfilled w/ bentonite chips
								27		
								28		
								29		
								30		
								31		
								32		
								33		
								34		
								35		
								36		
								37		
								38		
								39		
								40		

NOTES: General: USCS is modified for this log as follows:
Materials amounts are estimated by % volume instead of % weight.
(1) Badly broken core, accurate footage measurements not possible.
(2) Core breaks cannot be matched, accurate footage measurements not possible.

Procedure No. RMRS/OPS-PRO.101
Revision 0
Date effective: 12/31/98

U.S. DEPARTMENT OF ENERGY ROCKY FLATS PLANT FORM PRO.101A

ROCKY FLATS ENVIRONMENTAL TECHNOLOGY SITE BOREHOLE LOG

PAGE 1 OF 2

Borehole Number: B3
Location - North: East:
Date:
Geologist: Rick Heidrick
Drilling Equip.:
Surface Elevation:
Area:
Total Depth: 34'
Company:
Project No.: 57378
Sample Type:

RMRS LOGGING SUPERVISOR APPROVAL DATE

TOP/BOTTOM OF CORE IN BOX	TOP/BOTTOM OF INTERVAL	FEET OF CORE IN INTERVAL (FIELD MEASUREMENT)	SAMPLE NUMBER	FRACTURE ANGLE	BEDDING ANGLE	GRAIN SIZE DISTRIBUTION	USCS SYMBOL	DEPTH IN FEET	SOIL LITHOLOGIC LOG	SAMPLE DESCRIPTION
										Road Fill
X-1	Run 1	4.0'/4.0'	C-1				Qf	1–4		0'-13' (CL) GRAVELLY SANDY CLAY; varies dk. brn. to yellowish brn; 50% med. plstc clay; 25% fn to cse sand; 25% fn to cse gravel to 3"; damp; angular gravel/crushed rock; varies w/ depth to
	DR	0.7'/1.5'	L-1	15 16 10				5		→ SANDY CLAYEY GRAVEL
X-2	Run 2	3.5'/3.5'	C-1					6–8		CL olive gray mottled orange; 30% med. plstc clay 20% fn-med sand; 50% cse gravel to 3"
	P	2.0'/2.0'	S-1	150 250 500	C-1			9		
X-3	DR	0.2'/1.5'		6 12 13				10–11		10' Shelby refusal; 3" rock @ 10.0'
	DR	NR		7 9 13				12		COLLUVIUM
X-4	DR	NR		10 10 10			Qc	13–14		13'-16' (CL) LEAN CLAY w/ GRAVEL; orange; 60% med. to high plstc clay; 20% fn-cse gravel to 4"; rounded; 20% fn to cse sand PP=1.8 TV=6
	Run 3		C-1					15		15' becomes mottled grey
	DR	1.3'/1.5	L-2 L-3 L-4	2 6 7				16		BEDROCK
	DR	1.2'/1.5	L-5 L-6 L-7	8 13 15			CSSW	17		16'-17.5' CLAYSTONE; med. gray; sev. wthrd. to soil; v. soft & plstc;
							CSMW	18		CL soil-like; FAT CLAY, high plstc
X-5	P	2.2'/2.4'	S-2	200 500				19–20		v. stiff; moist; PP=2.2 FeO2 stained sltly carbonaceous TV=>10 over

NOTES: General: USCS is modified for this log as follows:
Materials amounts are estimated by % volume instead of % weight.
(1) Badly broken core, accurate footage measurements not possible.
(2) Core breaks cannot be matched, accurate footage measurements not possible.

Procedure No. RMRS/OPS-PRO.101
Revision 0
Date effective: 12/31/98

(401 1-930-0134-930X Form GT.1A)(03/01/97)

U.S. DEPARTMENT OF ENERGY ROCKY FLATS PLANT

FORM PRO.101A

ROCKY FLATS ENVIRONMENTAL TECHNOLOGY SITE BOREHOLE LOG

PAGE 2 OF 2

Borehole Number: B3
Location - North: East:
Date:
Geologist:
Drilling Equip.:

Surface Elevation:
Area:
Total Depth:
Company: Project No.: 57378
Sample Type:

RMRS LOGGING SUPERVISOR APPROVAL

DATE Dry to 28' 7/14/04

TOP/BOTTOM OF CORE IN BOX	TOP/BOTTOM OF INTERVAL	FEET OF CORE IN INTERVAL (FIELD MEASUREMENT)	SAMPLE NUMBER	FRACTURE ANGLE	BEDDING ANGLE	GRAIN SIZE DISTRIBUTION	USCS SYMBOL	DEPTH IN FEET	SOIL/ LITHOLOGIC LOG	SAMPLE DESCRIPTION
P			S-2						CSWW	17.5'-25.5' CLAYSTONE: crushed w/ hard
X-5								21		angular clay pieces in clay matrix.
	Run 4	3.5'/3.5	C-1					22		brecciated; matrix FeO2 stained.
X-6								23		20.5': PP>5; Occ. slks, rare
								24		carbon; mod. wthrd. ; little FeO2
	DR	1.3'/1.5	13 30 47	L-8 L-9 L-10				25		no bedding; Frac. s/c's FeO2 stained. 22' PP=3.0
X-6							CSW	26		24' PP>5
X-7	Run 5	3.5'/3.5	C-1					27		24-25.5' CLAYSTONE w/SANDSTONE
								28		25.5'-34' CLAYSTONE: V. dk. gray;
								29		unweathered; soft; weak; crushed;
	Run 6	5.0'/5.0'						30		disturbed; rare FeO2 stains; thinly laminated @ 10° dip.
								31		26.5'-29.5' brecciated
								32		30' rig chatter.
								33		29'-30' locally mod. wthrd.
								34		
								35		
								36		
								37		
								38		
								39		
								40		

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Materials amounts are estimated by % volume instead of % weight.
(1) Badly broken core, accurate footage measurements not possible.
(2) Core breaks cannot be matched, accurate footage measurements not possible.

Procedure No. RMRS/OPS-PRO.101
Revision 0
Date effective: 12/31/98

U.S. DEPARTMENT OF ENERGY ROCKY FLATS PLANT

FORM PRO.101A

ROCKY FLATS ENVIRONMENTAL TECHNOLOGY SITE BOREHOLE LOG

Borehole Number: B4
Location - North: ______ East: ______
Date: 6/24 + 6/25
Geologist: Rich Heldrich
Drilling Equip.: CME-75

Surface Elevation: ~5975
Area: ______
Total Depth: 34.0'
Company: Layne
Project No.: 57378
Sample Type: SPT, Cal.Mod, Shelby, Core

RMRS LOGGING SUPERVISOR
APPROVAL ______ DATE ______

TOP/BOTTOM OF CORE IN BOX	TOP/BOTTOM OF INTERVAL	FEET OF CORE IN INTERVAL (FIELD MEASUREMENT)	SAMPLE NUMBER	FRACTURE ANGLE	BEDDING ANGLE	GRAIN SIZE DISTRIBUTION	USCS SYMBOL	DEPTH IN FEET	SOIL LITHOLOGIC LOG	SAMPLE DESCRIPTION
		3.7					Qf		0	Road Fill
X-1	Run 1	4.0	C-1					1		0'-8.5' SANDY CLAYEY GRAVEL w/COBBLES;
								2		(GC) reddish brown to dark brown; fn + cse gravel + cobbles to 8"; 80% med plstc. clay; 20% fn to cse sand.
								3		
								4		
X-2								5	0	
	Run 2	5.0 / 5.0						6		
								7		COLLUVIUM
								8		8.5'-14'? SANDY CLAY; dk. brn.; 70% med. plstc clay; 30% fn. sand; rare fn. gravel; moist; stiff; pp = 1.75
							Qc	9		(CL)
X-?	DR	8 / 6 / 9	L-1 L-2 L-3					10		mixed w/ pieces of CSSW claystone / lean clay
	P	1.2 / 1.2	S1	100-250 psi				11		LEAN CLAY; med. plstc; caliche nodules sev. wthrd claystone in Qc
	P	2.0 / 2.5	S2	250 400				12		
								13		BEDROCK
							CSSW	14		14'?-17 CSSW CLAYSTONE; med. gray; sev. wthrd. v. soft; plstc; wthrd to clay; extensively FeO2 stained PP = 2.3; v. stiff; some caliche nodules; slks @ 18
	P	2.0 / 2.5	S3	100 250 400				15		
								16		
							CSMW	17		
X-3	Run 3	2.0 / 2.0	C-1					18		17'-29' CLAYSTONE: mod. wthrd; locally crushed w/ slicks + heavy FeO2 stains; intensely frac'd. + laminated bedding w/ depth.
	DR	1.4 / 1.5	L-4 L-5	19 / 12	9 / 12			19		
								20		

NOTES: General: USCS is modified for this log as follows:
Materials amounts are estimated by % volume instead of % weight.
(1) Badly broken core, accurate footage measurements not possible.
(2) Core breaks cannot be matched, accurate footage measurements not possible.

Procedure No. RMRS/OPS-PRO.101
Revision 0
Date effective: 12/31/98

(4011-930-0134-930)(Form GT.1A)(03/01/97)

U.S. DEPARTMENT OF ENERGY ROCKY FLATS PLANT

FORM PRO.101A

ROCKY FLATS ENVIRONMENTAL TECHNOLOGY SITE BOREHOLE LOG

Borehole Number: B4
Location - North: ______ East: ______
Date: ______
Geologist: ______
Drilling Equip.: ______
Surface Elevation: ______
Area: ______
Total Depth: ______
Company: ______ Project No.: 57378
Sample Type: ______

RMRS LOGGING SUPERVISOR
APPROVAL ______ DATE ______

TOP/BOTTOM OF CORE IN BOX	TOP/BOTTOM OF INTERVAL	FEET OF CORE IN INTERVAL (FIELD MEASUREMENT)	SAMPLE NUMBER	FRACTURE ANGLE	BEDDING ANGLE	GRAIN SIZE DISTRIBUTION	USCS SYMBOL	DEPTH IN FEET	SOIL/ LITHOLOGIC LOG	SAMPLE DESCRIPTION
	DR		L6	25					CS mw	
X-3	C	3.5/3.5	C-1					21		22' closely frac'd; frac sfcs heavily FeOx stained; soft; weak; PP=+5
								22		
X-4								23		
								24		24' becomes thinly laminated; soft; weak to mod. strong; minor FeOx stains on frac. planes.
		5.0/5.0						25		
								26		
X-5								27		
								28		
								29	CS UW	29'-34' CSUW CLAYSTONE; med. gray; unweathered soft; weak; no FeOx, ~10% carbonaceous deposits; horiz. laminated to thinly laminated
		5.0/5.0						30		
X-6								31		
								32		
								33		
								34		Backfilled w/ bentonite chips
								35		
								36		
								37		
								38		
								39		
								40		

22.5'

NOTES: General: USCS is modified for this log as follows:
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(1) Badly broken core, accurate footage measurements not possible.
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Procedure No. RMRS/OPS-PRO.101
Revision 0
Date effective: 12/31/98

U.S. DEPARTMENT OF ENERGY ROCKY FLATS PLANT FORM PRO.101A

ROCKY FLATS ENVIRONMENTAL TECHNOLOGY SITE BOREHOLE LOG

PAGE 1 OF 2

Borehole Number: B4A
Location - North: East:
Date: 6/23/04
Geologist: Rick Heidrick
Drilling Equip.: CME-75

Surface Elevation: ~5975
Area: RF OLF
Total Depth: 33.5
Company: Layne Project No.: 57378
Sample Type: Continuous Core 5'x3"

RMRS LOGGING SUPERVISOR APPROVAL DATE 6/23/04

TOP/BOTTOM OF CORE IN BOX	TOP/BOTTOM OF INTERVAL	FEET OF CORE IN INTERVAL (FIELD MEASUREMENT)	SAMPLE NUMBER	FRACTURE ANGLE	BEDDING ANGLE	GRAIN SIZE DISTRIBUTION	USCS SYMBOL	DEPTH IN FEET	SOIL LITHOLOGIC LOG	SAMPLE DESCRIPTION
										Advance boring using 8" hollow stem augers continuous core sampling using 5'x3½ sample barrel advanced ahead of auger bit. Road Fill
X-1	Run 1	1.2 / 2.5 / 2.0 / 4.0					Qf	1		0'-9' GC SANDY CLAYEY GRAVEL w/ COBBLES dark brown; 50% gravel + cobbles to 6"; rounded; 25% med. plstc clay; 25% fn. sand appears med. dense; moist; appears derived from Rocky Flats Alluvium.
		NR						2, 3, 4		
	Run 2	2.5 / 2.5	C1					5, 6		
NR	Run 3	0.5 / 2.5	No liner					7, 8		~9' cuttings of SC/CL. COLLUVIUM
X-2	Run 4	0.5 / 2.5					Qc	9, 10, 11		9'-16'. Qc SANDY CLAY; dk brn; ~70% med. plstc clay ~30% fn to cse sand; moist; appears firm.
	Run 5	0.5 / 2.5						12, 13, 14		9'-14' Soil in core barrel is in form of clay shavings, possible cobble lodged in auger bit. Pull augers, No obstruction. Enter hole + drive cal Mod
	Run 6	1.0 / 2.5						15		BEDROCK
X-3	Run 7	2.0 / 2.5					CSSW	16, 17	CSSW	16'-18' CLAYSTONE; med. gry; sev. wthed; extensive FeOx staining in matrix; stiff; v. soft; plastic. pp= 66 @ 16.2'; moist; crushed & intensely frac'd.
	OR CM	27 / 27 / 33	1.5 / 1.5				CSMW	18, 19, 20	CSMW	18'-30', becomes MW, less FeOx; intensely to closely frac'd; smooth frac sfcs. soft, friable damp.

NOTES: General: USCS is modified for this log as follows:
Materials amounts are estimated by % volume instead of % weight.
(1) Badly broken core, accurate footage measurements not possible.
(2) Core breaks cannot be matched, accurate footage measurements not possible.

Procedure No. RMRS/OPS-PRO.101
Revision 0
Date effective: 12/31/98

1-4011-430-0134-930X(Form GT.1A)(03/01/97)

U.S. DEPARTMENT OF ENERGY ROCKY FLATS PLANT — FORM PRO.101A

ROCKY FLATS ENVIRONMENTAL TECHNOLOGY SITE BOREHOLE LOG

PAGE 2 OF 2

Borehole Number: B4A
Location - North: ______ East: ______
Date: 6/23/04
Geologist: R.H.
Drilling Equip.: ______
Surface Elevation: ______
Area: ______
Total Depth: 33.5
Company: ______
Project No.: 57378
Sample Type: ______

RMRS LOGGING SUPERVISOR APPROVAL ______ DATE Moist @ 23' 7/14/04

TOP/BOTTOM OF CORE IN BOX	TOP/BOTTOM OF INTERVAL	FEET OF CORE IN INTERVAL (FIELD MEASUREMENT)	SAMPLE NUMBER	FRACTURE ANGLE	BEDDING ANGLE	GRAIN SIZE DISTRIBUTION	USCS SYMBOL	DEPTH IN FEET	SOIL/LITHOLOGIC LOG	SAMPLE DESCRIPTION
X4	DR	50 50/2	NR					21	CS SW	CSww cont. 20.5' less FeO2; deposited as small (~3 mm) nodule at vert fracs. sfcs.
	HA							22		Augered to 22' w/ core barrel; recovered 8" rock in core.
	DR SPT	10 23 29	1.4'/1.5'					23		
	Run 8	2.8'/2.5' *						24, 25, 26		25' heavy FeO2 in 70° joint sfc. 26' Mod. frac'd, subvert. joints w/ heavy FeO2; laminated w/ fn grained sandstone; claystone bedding laminated to thinly laminated.
X-5	Run 9	3.5'/2.5' *						27, 28		
X6	Run 10	3.0'/5.0'	w/ acrylic liner					29, 30, 31, 32, 33	CS UW	30'-33.5' CLAYSTONE; unweathered; dark gray; soft; weak; mod. frac'd. @ high angles; absence of FeO2; laminated bedding present; some carbon layers; dry. acrylic liner crushed in core barrel @ 3' blocking clay from full recovery.
								34		Dry @ completion of boring @ 1415.
								35, 36, 37, 38, 39, 40		

NOTES: General: USCS is modified for this log as follows:
Materials amounts are estimated by % volume instead of % weight.
(1) Badly broken core, accurate footage measurements not possible.
(2) Core breaks cannot be matched, accurate footage measurements not possible.

Procedure No. RMRS/OPS-PRO.101
Revision 0
Date effective: 12/31/98

* clay extends in core barrel ~ 50%

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U.S. DEPARTMENT OF ENERGY ROCKY FLATS PLANT — FORM PRO.101A

ROCKY FLATS ENVIRONMENTAL TECHNOLOGY SITE BOREHOLE LOG

Borehole Number: B5
Location - North: ______ East: ______
Date: 6/28/04
Geologist: Rick Heidrick
Drilling Equip.: CME-75

Surface Elevation: ~5,970
Area: ______
Total Depth: 42.0'
Company: ______ Project No.: 57378
Sample Type: ______

RMRS LOGGING SUPERVISOR APPROVAL ______ DATE ______

TOP/BOTTOM OF CORE IN BOX	TOP/BOTTOM OF INTERVAL	FEET OF CORE IN INTERVAL (FIELD MEASUREMENT)	SAMPLE NUMBER	FRACTURE ANGLE	BEDDING ANGLE	GRAIN SIZE DISTRIBUTION	USCS SYMBOL	DEPTH IN FEET	SOIL/LITHOLOGIC LOG	SAMPLE DESCRIPTION
										FILL
X-1	Run 1	3.0'/4.0'	C-1				Qf	1	CL	0'-10.5' (CL) GRAVELLY CLAY med. brn.; ~50% med plstc clay fn. to cse gravel; mixed w/ clayey sand ~~+~~ sandy clay moist to damp
								2		
								3		
								4		
	Run 2	3.5'/5.0'						5		
								6		
X-2								7		
								8		
								9		
	Run 3	3.4'/5.0'						10		COLLUVIUM
							Qc	11	Qc	10.5'-37' (CL/GC) GRAVELLY SANDY CLAY, reddish brn.; gray + yellowish brn.; ~40% med. plstc. clay ~30% fn. to cse. gravel; ~30% fn. to cse sand; percent varies w/ depth; moist; lean clay w/ gravelly lenses + clayey sand lenses, mixed w/ depth, some clayey gravel.
X-3								12		
								13		
								14		
	DR	1.3'/1.5	L1 L2 L3	3 5 6				15		12.5'-13.5' clayey sand w/ gravel
								16		
X-3	Run 4	3.5'/3.5		C-1				17		no slide planes or zones
								18		
								19		
X-4	Run 5							20		

NOTES: General: USCS is modified for this log as follows:
Materials amounts are estimated by % volume instead of % weight.
(1) Badly broken core, accurate footage measurements not possible.
(2) Core breaks cannot be matched, accurate footage measurements not possible.

Procedure No. RMRS/OPS-PRO.101
Revision 0
Date effective: 12/31/98

(4011-930-0134-930)(Form GT.1A)(03/01/92)

U.S. DEPARTMENT OF ENERGY ROCKY FLATS PLANT **FORM PRO.101A**

ROCKY FLATS ENVIRONMENTAL TECHNOLOGY SITE BOREHOLE LOG

Borehole Number: B5
Location - North: ______ East: ______
Date: ______
Geologist: ______
Drilling Equip.: ______

Surface Elevation: ______
Area: ______
Total Depth: ______
Company: ______ Project No.: 57378
Sample Type: ______

RMRS LOGGING SUPERVISOR APPROVAL ______ DATE Moist @ 31' 7/14/04

TOP/BOTTOM OF CORE IN BOX	TOP/BOTTOM OF INTERVAL	FEET OF CORE IN INTERVAL (FIELD MEASUREMENT)	SAMPLE NUMBER	FRACTURE ANGLE	BEDDING ANGLE	GRAIN SIZE DISTRIBUTION	USCS SYMBOL	DEPTH IN FEET	SOIL LITHOLOGIC LOG	SAMPLE DESCRIPTION
X-4	Run 5	2.5'/3.0	C-1				Qc	21		20.5'-24' GRAVELLY CLAY; med. plsty. wet.
	P	2.1'/2.3	S-1	100-400 psi				22, 23		
	P	1.9'/2.3'	S-2	100-400				24, 25, 26		24'-25' Tube drilled, gravelly. 25'-27' sandy clay w/ gravel (FeO2 stained
	DR	1.5'/1.5'	L4 L5 L6	4 7 11				27		27' FeO2 stained
	P	1.0'/2.5	S3	500 psi				28, 29, 30		29'-30.5' CLAYEY GRAVEL
X-4 X-5	Run 6	3.5'/3.5	C-1		B5a			31, 32		
					30 50/3"	L-1 L-2		33		BEDROCK
					50/3"	NR				
	DR	NR	NR	50/6"	HA	HA	CSMW	34	CSMW	37'-38' CLAYSTONE: yellowish brn. w/ red + wt. mottling; mod. wthr'd.; soft friable; no slide planes/zones.
X-5	Run 7	0.5'/1.5	C-1		100/4"	NR		35		
	DR	NR		150/6"				36		
	DR	NR		200/5"	150	6"	NR	37		
	HA				30 100/4"	0.7'/0.7	L3 L4	38		38'-42' CLAYSTONE; dk. gray; fresh; soft; friable; thinly laminated; dry; intact + in place.
	DR	0.4'/0.7	L7	41 50/3"				39, 40		

NOTES: General: USCS is modified for this log as follows:
Materials amounts are estimated by % volume instead of % weight.
(1) Badly broken core, accurate footage measurements not possible.
(2) Core breaks cannot be matched, accurate footage measurements not possible.

Procedure No. RMRS/OPS-PRO.101
Revision 0
Date effective: 12/31/98

CM

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4011-930-0134-930 Form GT.1A(09/01/92)

U.S. DEPARTMENT OF ENERGY ROCKY FLATS PLANT

FORM PRO.101A

ROCKY FLATS ENVIRONMENTAL TECHNOLOGY SITE BOREHOLE LOG

PAGE ~~2~~ 3 OF 3

Borehole Number: B5
Location - North: ________ East: ________
Date: ________
Geologist: ________
Drilling Equip.: ________

Surface Elevation: ________
Area: ________
Total Depth: ________
Company: ________ Project No.: 57378
Sample Type: ________

RMRS LOGGING SUPERVISOR
APPROVAL ________ DATE ________

TOP/BOTTOM OF CORE IN BOX	TOP/BOTTOM OF INTERVAL	FEET OF CORE IN INTERVAL (FIELD MEASUREMENT)	SAMPLE NUMBER	FRACTURE ANGLE	BEDDING ANGLE	GRAIN SIZE DISTRIBUTION	USCS SYMBOL	DEPTH IN FEET	SOIL/LITHOLOGIC LOG	SAMPLE DESCRIPTION
X-5	Run 8	2.5/2.5	C-1				CSLW	41		"40'-42' becomes laminated.
								42		
								43		
								44		
								45		
								46		
								47		
								48		
								49		
								~~10~~ 50		
								11		
								12		
								13		
								14		
								15		
								16		
								17		
								18		
								19		
								20		

NOTES: General: USCS is modified for this log as follows:
Materials amounts are estimated by % volume instead of % weight.
(1) Badly broken core, accurate footage measurements not possible.
(2) Core breaks cannot be matched, accurate footage measurements not possible.

Procedure No. RMRS/OPS-PRO.101
Revision 0
Date effective: 12/31/98

(401) 930-0134-930 (Form GT.1A)(03/01/97)

U.S. DEPARTMENT OF ENERGY ROCKY FLATS PLANT **FORM PRO.101A**

ROCKY FLATS ENVIRONMENTAL TECHNOLOGY SITE BOREHOLE LOG

PAGE 1 OF ___

Borehole Number: B6
Location - North: ________ East: ________
Date: 7/9/04
Geologist: Rich Heidrich
Drilling Equip.: CME-75

Surface Elevation: ________
Area: S. of Road
Total Depth: ________
Company: ________ Project No.: 57378
Sample Type: ________

RMRS LOGGING SUPERVISOR
APPROVAL ________ DATE ________

TOP/BOTTOM OF CORE IN BOX	TOP/BOTTOM OF INTERVAL	FEET OF CORE IN INTERVAL (FIELD MEASUREMENT)	SAMPLE NUMBER	FRACTURE ANGLE	BEDDING ANGLE	GRAIN SIZE DISTRIBUTION	USCS SYMBOL	DEPTH IN FEET	SOIL LITHOLOGIC LOG	SAMPLE DESCRIPTION Road Fill
X-1	Run 1	3.0/4.0	C-1				Qf	1 2 3 4		0-5' SANDY CLAY w/ GRAVEL: lt. to dk. brn.; 70% med plstc clay; 20% fn. sand; 10% fn-cse gravel, angular; stiff.
	DR	NR	-	5 6 9				5		COLLUVIUM 5'-11' LEAN CLAY w/ GRAVEL; v. dk brn. 70% med. to high plstc. clay; 20% fn + cse gravel to 5; rounded; moist
X-1	DR	NR		5 5 9			Qc	6 7		stiff; 10% fn. sand PP = 0.7 + 1.3
X-2	Run 2		C-1					8		gravelly layers TV = 5.2.
x	DR	1.0'/1.5	L-1 L-2	4 5 6				9		
x-2	Run 3	1.5/1.5	C-1					10 11		BEDROCK
X-3	P	1.1/2.4	S-1	0 50 P			CSSW	12 13		11'-14.0' CLAYSTONE: med. gray w/ orange; sev. wthrd to soil; v. soft; plstc.; Soil-like Lean Clay w/ Sand; Moist; v. stiff; PP = 2.1; locally FeO2 stained throughout. PP=0.2
	DR	1.4/1.5	L-3 L-4 L-5	4 7 10			CSHW	14 15		
x-3	Run 4	4.0/4.0	C-1					16 17		14.0'-33.0' CLAYSTONE; med. gray w/ some orange; mod. wthrd.; soft; friable to weak; locally
x-4								18 19		crushed cs in clay matrix
	DR	1.4/1.5	L-6 L-7	8 16				20		17.5'-18; 40° shear. Sev. wthrd.; slks; gravel concrete

NOTES: General: USCS is modified for this log as follows: 18'-18.5' crushed.
Materials amounts are estimated by % volume instead of % weight.
(1) Badly broken core, accurate footage measurements not possible.
(2) Core breaks cannot be matched, accurate footage measurements not possible.

Procedure No. RMRS/OPS-PRO.101
Revision 0
Date effective: 12/31/98
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(4011-930-0134-930) Form GT.1A (03/01/92)

ROCKY FLATS ENVIRONMENTAL TECHNOLOGY SITE BOREHOLE LOG

PAGE 2 OF 2

Borehole Number: B-6
Location - North: East:
Date:
Geologist:
Drilling Equip.:
Surface Elevation:
Area:
Total Depth:
Company:
Project No.: 57378
Sample Type:

RMRS LOGGING SUPERVISOR APPROVAL
DATE Dry to 31' 7/14/04

TOP/BOTTOM OF CORE IN BOX	TOP/BOTTOM OF INTERVAL	FEET OF CORE IN INTERVAL (FIELD MEASUREMENT)	SAMPLE NUMBER	FRACTURE ANGLE	BEDDING ANGLE	GRAIN SIZE DISTRIBUTION	USCS SYMBOL	DEPTH IN FEET	SOIL/LITHOLOGIC LOG	SAMPLE DESCRIPTION
	DR		L-8	26						vert. fracs FeOz coated, PP>5
X-5	Run 5	3.5'/3.5'	C-1					21		
								22		crushed
								23		23'-24' extensively FeOz stained
								24		24' horz. bedding; vert. fracs FeOz filled.
X-6	Run 6	2.5'/2.5	C-1					25		
								26		
	DR	0.8'/1.0	L-9 L-10	20 50/6"				27		28' SS/CS
	Run 7	1.5'/1.5	C-1					28		
								29		
X-7	Run 8	5.0'/5.0	C-1					30		
								31		
								32		
							CSUW	33		33'-38' CLAYSTONE: v.dk gray; fresh; mod. hard; weak to mod strong; horiz. thinly laminated bedding; no FeOz stains.
								34		
X-8	Run 9		C-1					35		
								36		
								37		
								38		Backfilled w/ bentonite chips.
								39		
								40		

NOTES: General: USCS is modified for this log as follows:
Materials amounts are estimated by % volume instead of % weight.
(1) Badly broken core, accurate footage measurements not possible.
(2) Core breaks cannot be matched, accurate footage measurements not possible.

Procedure No. RMRS/OPS-PRO.101
Revision 0
Date effective: 12/31/98

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ROCKY FLATS ENVIRONMENTAL TECHNOLOGY SITE BOREHOLE LOG

PAGE 1 OF 2

Borehole Number: B7
Location - North: ______ East: ______
Date: 6/29/04
Geologist: Rick Heldrich
Drilling Equip.: CME-75

Surface Elevation: ______
Area: RFOLF
Total Depth: 36.5'
Company: ______ Project No.: 57378
Sample Type: ______

RMRS LOGGING SUPERVISOR APPROVAL ______ DATE GW @ 10.9' on 7/14/04

TOP/BOTTOM OF CORE IN BOX	TOP/BOTTOM OF INTERVAL	FEET OF CORE IN INTERVAL (FIELD MEASUREMENT)	SAMPLE NUMBER	FRACTURE ANGLE	BEDDING ANGLE	GRAIN SIZE DISTRIBUTION	USCS SYMBOL	DEPTH IN FEET	SOIL/LITHOLOGIC LOG	SAMPLE DESCRIPTION
										Road Fill
X1	Run 1	4.0/4.0	C-1				QF	1	CL	0'-3' GRAVELLY SANDY CLAY; med gray ~60% med. plstc clay; ~20% fn+cse gravel; ~20% fn+med. sand; moist.
								2		
								3		
								4	GC	3'-6' (GC) CLAYEY SANDY GRAVEL: lt. brn; 60% fn+cse gravel 20% sand w clay; damp
X-2	Run 2	2.6/4.0						5		COLLUVIUM
							Qc	6		6'-11.5' (CL) LEAN CLAY w/ SAND: olive to dk. brn; 80% med. plstc clay; 20% occ sand lenses randomly oriented; moist; stiff (PP=1.8); gravelly @ depth
								7	Qc	
	DR	1.5/1.5	L1 L2 L3	2 4 4				8		
								9	Qc	8'-11.5' (CL) becomes SANDY CLAY w/ GRAVEL: dk. brn; 60% med. plstc. clay; 20% rounded fn. gravel; 20% fn to cse sand; moist
X-2	Run 3	2.0/2.0	C-1					10		
								11		9.5'-11.5' ~10% fn. gravel
	DR	1.5/1.5	L4 L5 L6	3 4 6			CSSW	12	CSSW	11' PP=1.3
								13		BEDROCK 11.5'-17.5' CLAYSTONE; olive gray, mottled w/ + reddish brn.; sev. wthrd. to resid. soil; v. soft; plstc.; soil like qualities - LEAN CLAY w/ SAND; 90% med. plstc clay; 10% fn. sand; FeOx stains in veins, caliche nodules; moist; rare gravel (1%?) firm (PP=0.9)
	P	2.0/2.0	S-2	150 psi				14		
								15		15.5' PP=1.7
X-3	Run 4	2.0/2.0	C-1					16		
								17		17.5' PP=1.0 CLAYSTONE; mod. wthrd.;
	DR	1.5/1.5	L7 L8 L9	4 8 13			CSHW	18		17.5'-33' grey little FeOx, no caliche; failure zone 17.5'-
								19		dry; soft; friable; brecciated; crumples to 1/2-1/4" angular pieces; locally FeOx staining.
	DR	1.4/1.5	L10 L11	5 13				20		

shelby core in band

NOTES: General: USCS is modified for this log as follows:
Materials amounts are estimated by % volume instead of % weight.
(1) Badly broken core, accurate footage measurements not possible.
(2) Core breaks cannot be matched, accurate footage measurements not possible.

Procedure No. RMRS/OPS-PRO.101
Revision 0
Date effective: 12/31/98

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(4011-430-0134-930) Form CT.LA K03/01/92

U.S. DEPARTMENT OF ENERGY ROCKY FLATS PLANT

FORM PRO.101A

ROCKY FLATS ENVIRONMENTAL TECHNOLOGY SITE BOREHOLE LOG

PAGE 2 OF 2

Borehole Number: B7

Location - North: ______ East: ______

Date: ______

Geologist: ______

Drilling Equip.: ______

Surface Elevation: ______

Area: ______

Total Depth: 36.5'

Company: ______

Project No.: 57378

Sample Type: ______

RMRS LOGGING SUPERVISOR APPROVAL ______ DATE ______

TOP/BOTTOM OF CORE IN BOX	TOP/BOTTOM OF INTERVAL	FEET OF CORE IN INTERVAL (FIELD MEASUREMENT)	SAMPLE NUMBER	FRACTURE ANGLE	BEDDING ANGLE	GRAIN SIZE DISTRIBUTION	USCS SYMBOL	DEPTH IN FEET	SOIL/LITHOLOGIC LOG	SAMPLE DESCRIPTION
	DR		L12	27			CSMW			20-20.5' locally FeOx stained intensely frac'd.; sub horiz bedding FeOx stain bedding planes; mostly orange; some gray; locally crushed.
X-3	Run 5	3.5'/3.5'	C-1					21		
								22		
								23		20.5'-21.5' V. soft to soft pp=0.2 mechanicaly disturbed from over drilling "cal Hod" mixed w/ gravel.
X-4								24		
	Run 6	5.0'/5.0'						25		21.5'-23' crushed
								26		
								27		24'-26' subvert. frac. FeOx filled, water conduit. 24' becomes mod. frac'd, locally crushed; smooth sfcs / slks. on fracs.
								28		
X-5								29		27' pp+5
	Run 7	2.5'/2.5'						30		28.5' minor FeOx
								31		
	DR	1.3'/1.5'	L13 L14 L15	LO 36 42				32		
							CSUW	33		33'-36.5' CLAYSTONE; dk gray; slightly wthrd.; soft to mod. hard; weak to mod. strong; mod frac'd.; laminated; dry; occ rare sandstone beds.
X-6	Run 8							34		
								35		
								36		36'-36.5' FeOx stained
								37		Backfilled w/ bentonite chips.
								38		
								39		
								40		

NOTES: General: USCS is modified for this log as follows:
Materials amounts are estimated by % volume instead of % weight.
(1) Badly broken core, accurate footage measurements not possible.
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Procedure No. RMRS/OPS-PRO.101
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[illegible] Form GT.1A(03/01/93)

U.S. DEPARTMENT OF ENERGY ROCKY FLATS PLANT — FORM PRO.101A

B8a 0'-4.5' B8b 0'-17' B8c 0'-25

ROCKY FLATS ENVIRONMENTAL TECHNOLOGY SITE BOREHOLE LOG

PAGE 1 OF __

Borehole Number: B8b&c
Location - North: ___ East: ___
Date: 7/1/04
Geologist: Rick Heldrick
Drilling Equip.: CME75 All Terrain Rig

Surface Elevation: ~5950
Area: Woman Creek
Total Depth: 25'
Company: ___
Project No.: 57378
Sample Type: ___

RMRS LOGGING SUPERVISOR APPROVAL ___ DATE G.W. @ 9.2' on 7/14/04

TOP/BOTTOM OF CORE IN BOX	TOP/BOTTOM OF INTERVAL	FEET OF CORE IN INTERVAL (FIELD MEASUREMENT)	SAMPLE NUMBER	FRACTURE ANGLE	BEDDING ANGLE	GRAIN SIZE DISTRIBUTION	USCS SYMBOL	DEPTH IN FEET	SOIL LITHOLOGIC LOG	SAMPLE DESCRIPTION
										COLLUVIUM Qc Qls
X-1	Run 1	4.5/5	C-1				Qls / Qc	1		0'-1.5' (CL) LEAN CLAY; med brn; 90% med plstc clay; 10% fn sand; moist; stiff pp=1¼
B8b								2		1.5'-8.0' (CL) SANDY CLAY w/ GRAVEL; med brn; 50% med plstc clay; 30% fn-cse gravel to 3"; 20% fn-cse sand; damp; occ cobbles & boulders.
								3		
								4		
						B8c		5		slide zone?,
X-2	Run 2	3.5'/5.0	B8C 7'-10' Core Box	P	2.2/2.4	S1 300		6		6'-8' LEAN CLAY; med. gray; 90% med plstc clay; 10% fn sand locally FeOx stained moist; v. stiff; PP=2.3 tsf TV=8
						500		7		
						Qa	Qa	8		dep. contact? slide zone? slide zone contact?
								9		ALLUVIUM
										8.0'-14.5' SANDY CLAYEY GRAVEL; dk brn; 50% rounded fn-cse gravel; 30% high plstc clay; 20% fn to cse sand; wet; med dense, 9'-10' PP=0.7; TV=2.0
	DR	0.5'/1.5	L1	10 8 10				10		
	DR	0.5'/1.0'	L2	21 50/5				11		
								12		13'- 60% gravel 20% sand, 20% clay
X-3	Run 3	1.5/1.5	C-1			B8c		13		BEDROCK No slide plane
	DR	0.6'/1.5	L3	12 12 19	DR 5 /8	NR	CSW	14		14.5'-18' CLAYSTONE; med gray w/ orange wt. caliche Mottling; v. soft to soft; plstc to friable; crushed pieces in soft clay matrix; soil-like → v. stiff med-high plsty PP=2.4 moist to wet
	DR	NR		29 30 38	2.1/2.4	S2 P 600 psi		15		
								16		
								17		
B8C X-2	Run 4				C-1	2.0/2.0'	CSHW	18		18'-22' CLAYSTONE; dk gray w/ some orange; mod. wthrd; Soft; weak; FeOx on frac. SCs. laminated bedding; intensely fractured in places
								19		
								20		

NOTES: General: USCS is modified for this log as follows:
Materials amounts are estimated by % volume instead of % weight.
(1) Badly broken core, accurate footage measurements not possible.
(2) Core breaks cannot be matched, accurate footage measurements not possible.

Procedure No. RMRS/OPS-PRO.101
Revision 0
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(401-430-0134-930) Form GT.1A(03/01/93)

U.S. DEPARTMENT OF ENERGY ROCKY FLATS PLANT

FORM PRO.101A

ROCKY FLATS ENVIRONMENTAL TECHNOLOGY SITE BOREHOLE LOG

Borehole Number: B8
Location - North: ________ East: ________
Date: ________
Geologist: ________
Drilling Equip.: ________

Surface Elevation: ________
Area: ________
Total Depth: ________
Company: ________ Project No.: 57378
Sample Type: ________

RMRS LOGGING SUPERVISOR APPROVAL ________ DATE ________

TOP/BOTTOM OF CORE IN BOX	TOP/BOTTOM OF INTERVAL	FEET OF CORE IN INTERVAL (FIELD MEASUREMENT)	SAMPLE NUMBER	FRACTURE ANGLE	BEDDING ANGLE	GRAIN SIZE DISTRIBUTION	USCS SYMBOL	DEPTH IN FEET	SOIL/ LITHOLOGIC LOG	SAMPLE DESCRIPTION
B8C X-3	Run 5	5.0/5.0'	C-1				CSMW	21	CSMW	20-22' FeO2 staind thrught mtrx.
							CSUW	22, 23, 24	CSUW	22'-25' CLAYSTONE; dk gray; fresh/unweathered; no discoloration; soft to mod. hard; weak to mod. strong; thinly laminated @ 20°; sltly carbonaceous; in place; little frac'd.
								25, 26, 27, 28, 29, 30, 31, 32, 33, 34, 35, 36, 37, 38, 39, 40		Backfilled w/ bentonite chips.

NOTES: General: USCS is modified for this log as follows:
Materials amounts are estimated by % volume instead of % weight.
(1) Badly broken core, accurate footage measurements not possible.
(2) Core breaks cannot be matched, accurate footage measurements not possible.

Procedure No. RMRS/OPS-PRO.101
Revision 0
Date effective: 12/31/98

(4011-430-0134-930)(Form GT.1A)(03/01/92)

U.S. DEPARTMENT OF ENERGY- ROCKY FLATS PLANT

FORM PRO.101A

ROCKY FLATS ENVIRONMENTAL TECHNOLOGY SITE BOREHOLE LOG

Borehole Number: B-9 (B9a offset)
Location - North: / East:
Date: 7/6/04 + 7/7
Geologist: Rick Heidrick
Drilling Equip.: All Terrain CME-75

Surface Elevation: ~5950
Area: Woman Creek
Total Depth: 25'
Company:
Project No.: 57378
Sample Type:

RMRS LOGGING SUPERVISOR APPROVAL

DATE GW e 4.4' on 7/14/04

TOP/BOTTOM OF CORE IN BOX	TOP/BOTTOM OF INTERVAL	FEET OF CORE IN INTERVAL (FIELD MEASUREMENT)	SAMPLE NUMBER	FRACTURE ANGLE	BEDDING ANGLE	GRAIN SIZE DISTRIBUTION	USCS SYMBOL	DEPTH IN FEET	SOIL LITHOLOGIC LOG	SAMPLE DESCRIPTION ALLUVIUM
X-1	Run 1	5.0' / 5.0	C-1	C	B9a		Qa	1		0'-6.7' SANDY LEAN CLAY; v. dk brn.; ~70% med. plstc clay; 30% fn to csc sand; moist; firm; PP=0.5-1.0
				P 0 psi	S1	1.5' / 2.4'		2		(CL) TV=4.0. wet e 4.5'; occ. rounded gravel to 1½".
								3		
				DR	L-1 L-2 L-3	2 4 7	1.3' / 1.5'	4		
								5		
X-2	DR	1.2' / 1.5'	L-1 L-2 L-3	2 6 23				6		6' becomes gravelly; 50% clay; 30% sand; 20% fn. gravel.
	C	1.0 / 1.5	L4 L5	26 6 12			CSSW	7	CSSW	BEDROCK
								8		6.7'-11' CLAYSTONE; med. gray; sev. wthrd to residual soil; v. soft; caliche
	DR	1.3 / 1.5	L-6 L-7 L-8	18 9 13				9		nodules; plstc.; no bedding. Soil-like lean to
	P	1.5 / 1.5	S-1	300 500 600 psi				10		Fat Clay w/ sand: PP=2.2 1.5; TV=7.0
							CSMW	11	CSMW	
X-3	Run 2	4.0' / 4.0'	C-1					12		9' becomes crushed in clay matrix. PP=1.5 TV=7
								13		11 Shelby refusal.
								14		
								15		11'-15' Some slks on frac sfc's; water on frac sfcs
X-4	Run 3	5.0' / 5.0'	C-1					16		11'-23' CLAYSTONE; med. gray; mod. wthrd;
								17		soft; weak; faint thinly laminated 20° bedding; crushed pieces in clay
								18		matrix; some slks on frac. sfc's.
								19		wet on frac. sfc's. PP=5+. Some FeO2 stains on vert. frac's.
								20		Some Carbon

NOTES: General: USCS is modified for this log as follows:
Materials amounts are estimated by % volume instead of % weight.
(1) Badly broken core, accurate footage measurements not possible.
(2) Core breaks cannot be matched, accurate footage measurements not possible.

Procedure No. RMRS/OPS-PRO.101
Revision 0
Date effective: 12/31/98

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U.S. DEPARTMENT OF ENERGY ROCKY FLATS PLANT FORM PRO.101A

ROCKY FLATS ENVIRONMENTAL TECHNOLOGY SITE BOREHOLE LOG

PAGE 2 OF 2

Borehole Number: B9
Location - North: East:
Date: 7/7/04
Geologist:
Drilling Equip.:

Surface Elevation:
Area:
Total Depth:
Company: Project No.: 57378
Sample Type:

RMRS LOGGING SUPERVISOR
APPROVAL DATE

TOP/BOTTOM OF CORE IN BOX	TOP/BOTTOM OF INTERVAL	FEET OF CORE IN INTERVAL (FIELD MEASUREMENT)	SAMPLE NUMBER	FRACTURE ANGLE	BEDDING ANGLE	GRAIN SIZE DISTRIBUTION	USCS SYMBOL	DEPTH IN FEET	SOIL LITHOLOGIC LOG	SAMPLE DESCRIPTION
									CSMW	
X-5	Run 4	4.5'/5.0'	C-1					21		
								22		
								23	CSUW	23'-25' CLAYSTONE; black; unweathered; soft to mod. hard; mod. strong; thinly laminated; in place.
								24		
								25		
								26		
								27		
								28		
								29		
								30		
								31		
								32		
								33		
								34		
								35		
								36		
								37		
								38		
								39		
								40		

NOTES: General: USCS is modified for this log as follows:
Materials amounts are estimated by % volume instead of % weight.
(1) Badly broken core, accurate footage measurements not possible.
(2) Core breaks cannot be matched, accurate footage measurements not possible.

Procedure No. RMRS/OPS-PRO.101
Revision 0
Date effective: 12/31/98

U.S. DEPARTMENT OF ENERGY ROCKY FLATS PLANT — FORM PRO.101A

ROCKY FLATS ENVIRONMENTAL TECHNOLOGY SITE BOREHOLE LOG

Borehole Number: B10
Location - North: ______ East: ______
Date: 7/7/04
Geologist: Rich Heidrick
Drilling Equip.: CME-75
Surface Elevation: ______
Area: ______
Total Depth: 34'
Company: ______
Project No.: 57378
Sample Type: ______

RMRS LOGGING SUPERVISOR APPROVAL ______ DATE G.W. @ 19.0' on 7/14/04

TOP/BOTTOM OF CORE IN BOX	TOP/BOTTOM OF INTERVAL	FEET OF CORE IN INTERVAL (FIELD MEASUREMENT)	SAMPLE NUMBER	FRACTURE ANGLE	BEDDING ANGLE	GRAIN SIZE DISTRIBUTION	USCS SYMBOL	DEPTH IN FEET	SOIL LITHOLOGIC LOG	SAMPLE DESCRIPTION Waste Fill
X-1	Run 1	2.0/4.0	C-1				Qf	1–4		0'-4' (CL) SANDY GRAVELLY CLAY; dk. to lt. brn. varies; ~40% med. plstc clay; 30% fn-med sand; 30% fn-crse gravel to 4"; moist; metal chards @ 1.5'.
	DR	1.4/1.5	L-1 L-2 L-3	4 14 15			Qc	5		COLLUVIUM 4'-6' LEAN CLAY w/ SAND; med. brn.; 80% med to high plstc clay; 10% fn. sand; 10% rounded gravel to 1"; damp PP=4.5; hard; gravel layer 5.5'-6.0'
X-1 / X-2	Run 2	3.5/3.5	C-1				CSMW	6–9		BEDROCK 6'-26.5' CLAYSTONE; med brn to orange; mod. wthrd.; FeO2 stained in clay matrix soft; weak; crushed pieces in clay matrix 6.5'-7.0'; 60° frac/shear plane, flat to wavy w/ slks, healed; shear zone 6'-9'?
	DR	1.2/1.5	L4 L5 L6	14 18 22				10		occ. fn gravel in CSMW; 7-9' crushed. PP>4.5; rare gravel concretions wthrd. to FeO2.
X-2 / X-3	Run 3	3.5/3.5	C-1					11–14		
X-4	Run 4	5.0/5.0	C-1					15–19	CSMW	12' occ. bedding @ 20°. 17.5'-18.0' SANDSTONE (SC) 18.5'-26.5' absence of FeO2.
	Run 5							20		

NOTES: General: USCS is modified for this log as follows:
Materials amounts are estimated by % volume instead of % weight.
(1) Badly broken core, accurate footage measurements not possible.
(2) Core breaks cannot be matched, accurate footage measurements not possible.

Procedure No. RMRS/OPS-PRO.101
Revision 0
Date effective: 12/31/98

(4011-930-0134-930)(Form CT.LA)(03/01/97)

U.S. DEPARTMENT OF ENERGY ROCKY FLATS PLANT

FORM PRO.101A

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ROCKY FLATS ENVIRONMENTAL TECHNOLOGY SITE BOREHOLE LOG

Borehole Number: B10
Location - North: ______ East: ______
Date: ______
Geologist: ______
Drilling Equip.: ______
Surface Elevation: ______
Area: ______
Total Depth: ______
Company: ______
Project No.: 57378
Sample Type: ______

RMRS LOGGING SUPERVISOR APPROVAL ______ DATE ______

TOP/BOTTOM OF CORE IN BOX	TOP/BOTTOM OF INTERVAL	FEET OF CORE IN INTERVAL (FIELD MEASUREMENT)	SAMPLE NUMBER	FRACTURE ANGLE	BEDDING ANGLE	GRAIN SIZE DISTRIBUTION	USCS SYMBOL	DEPTH IN FEET	SOIL LITHOLOGIC LOG	SAMPLE DESCRIPTION
X-4	Run 5	5.0'/5.0'	C-1				CSUW	21		20' increased sand content in CS bedding e 10°-20°; mod. FeO_2 stained.
								22		
X-5								23		
								24		24' Fn-rounded gravel (3/4".
	Run 6	5.0'/5.0'	C-1					25		
								26		26.5'-34' CLAYSTONE; blk; unweathered soft; weak; no apparent bedding; crushed; no FeO_2. PP>5; becomes thinly laminated w/ depth
X-6							CSUW	27		
								28		
								29		
	Run 7	5.0'/5.0'	C-1					30		26'-27.5' sheared a ~50°, slicks on shear sfc.
								31		29'-34' thinly laminated.
X-7								32		
								33		
								34		Backfilled w/ bentonite chips.
								35		
								36		
								37		
								38		
								39		
								40		

NOTES: General: USCS is modified for this log as follows:
Materials amounts are estimated by % volume instead of % weight.
(1) Badly broken core, accurate footage measurements not possible.
(2) Core breaks cannot be matched, accurate footage measurements not possible.

Procedure No. RMRS/OPS-PRO.101
Revision 0
Date effective: 12/31/98

1-4011-930-0134-930(Form CT.1A)(03/01/97)

U.S. DEPARTMENT OF ENERGY ROCKY FLATS PLANT | FORM PRO.101A

ROCKY FLATS ENVIRONMENTAL TECHNOLOGY SITE BOREHOLE LOG

PAGE 1 OF 1

Borehole Number: B-11
Location - North: East:
Date: 7/14/04
Geologist: Rick Heidrick
Drilling Equip.: CME-75

Surface Elevation:
Area: Near Women Creek
Total Depth: 14'
Company:
Project No.: 57378
Sample Type:

RMRS LOGGING SUPERVISOR APPROVAL

DATE Dry to 14' on 7/14/04

TOP/BOTTOM OF CORE IN BOX	TOP/BOTTOM OF INTERVAL	FEET OF CORE IN INTERVAL (FIELD MEASUREMENT)	SAMPLE NUMBER	FRACTURE ANGLE	BEDDING ANGLE	GRAIN SIZE DISTRIBUTION	USCS SYMBOL	DEPTH IN FEET	SOIL LITHOLOGIC LOG	SAMPLE DESCRIPTION COLLUVIUM
X-1	Run 1	4.0/4.0	C-1				Qc	1		0'-3' SC GRAVELLY SANDY CLAY. med. brn.; 50% med. plstc. clay; 25% fn to med. sand; 25% fn to cse gravel to 3"; damp; hard.
								2		
								3		
							Qof?	4	oO oO	3'-7.5' GW SANDY GRAVEL: wt. to lt. gray; 80% fn. to cse gravel, rounded; cobbles to 6"; dry.
	DR	1.1/1.5		14 40 43				5		
X-2	Run 2	1.5/1.5	C-1					6		BEDROCK
								7		7.5'-9' CLAYSTONE: med. gray mottled wt. sev. wthrd to residual soil; med. plsty.; damp; caliche nodules
	DR	NR	NR	28 23 32			CSSW	8		
X-2	Run 3	2/2	C-1					9		
	DR	1.5/1.5	L-1 L-2 L-3	9 23 37			CSHW	10		9'-12.5' CLAYSTONE: med. gray mottled orange; mod. wthrd. Some FeO2 staining along bedding + frac sfc's; soft friable to weak; dry.
X-3	Run 4	5/5	C-1					11		
								12		12.5'-14' CLAYSTONE; dk. grey to blk.; unwthrd.; mod. hd.; wk to mod. strong; dry.
							CSUW	13		
								14		Backfilled w/ bentonite chips.
								15		
								16		
								17		
								18		
								19		
								20		

didn't retain samples GW

NOTES: General: USCS is modified for this log as follows:
Materials amounts are estimated by % volume instead of % weight.
(1) Badly broken core, accurate footage measurements not possible.
(2) Core breaks cannot be matched, accurate footage measurements not possible.

Procedure No. RMRS/OPS-PRO.101
Revision 0
Date effective: 12/31/98

14011-930-0134-930/Form GT.1A(03/01/93)

U.S. DEPARTMENT OF ENERGY ROCKY FLATS PLANT | FORM PRO.101A

ROCKY FLATS ENVIRONMENTAL TECHNOLOGY SITE BOREHOLE LOG

PAGE 2 OF ___

Borehole Number: B
Location - North: ________ East: ________
Date: ________
Geologist: ________
Drilling Equip.: ________

Surface Elevation: ________
Area: ________
Total Depth: ________
Company: ________ Project No.: 57378
Sample Type: ________

RMRS LOGGING SUPERVISOR
APPROVAL ________ DATE ________

TOP/BOTTOM OF CORE IN BOX	TOP/BOTTOM OF INTERVAL	FEET OF CORE IN INTERVAL (FIELD MEASUREMENT)	SAMPLE NUMBER	FRACTURE ANGLE	BEDDING ANGLE	GRAIN SIZE DISTRIBUTION	USCS SYMBOL	DEPTH IN FEET	SOIL/ LITHOLOGIC LOG	SAMPLE DESCRIPTION
								21		
								22		
								23		
								24		
								25		
								26		
								27		
								28		
								29		
								30		
								31		
								32		
								33		
								34		
								35		
								36		
								37		
								38		
								39		
								40		

NOTES: General: USCS is modified for this log as follows:
Materials amounts are estimated by % volume instead of % weight.
(1) Badly broken core, accurate footage measurements not possible.
(2) Core breaks cannot be matched, accurate footage measurements not possible.

87

APPENDIX B

GEOTECHNICAL LABORATORY TEST DATA

88

APPENDIX B

GEOTECHNICAL LABORATORY TEST DATA

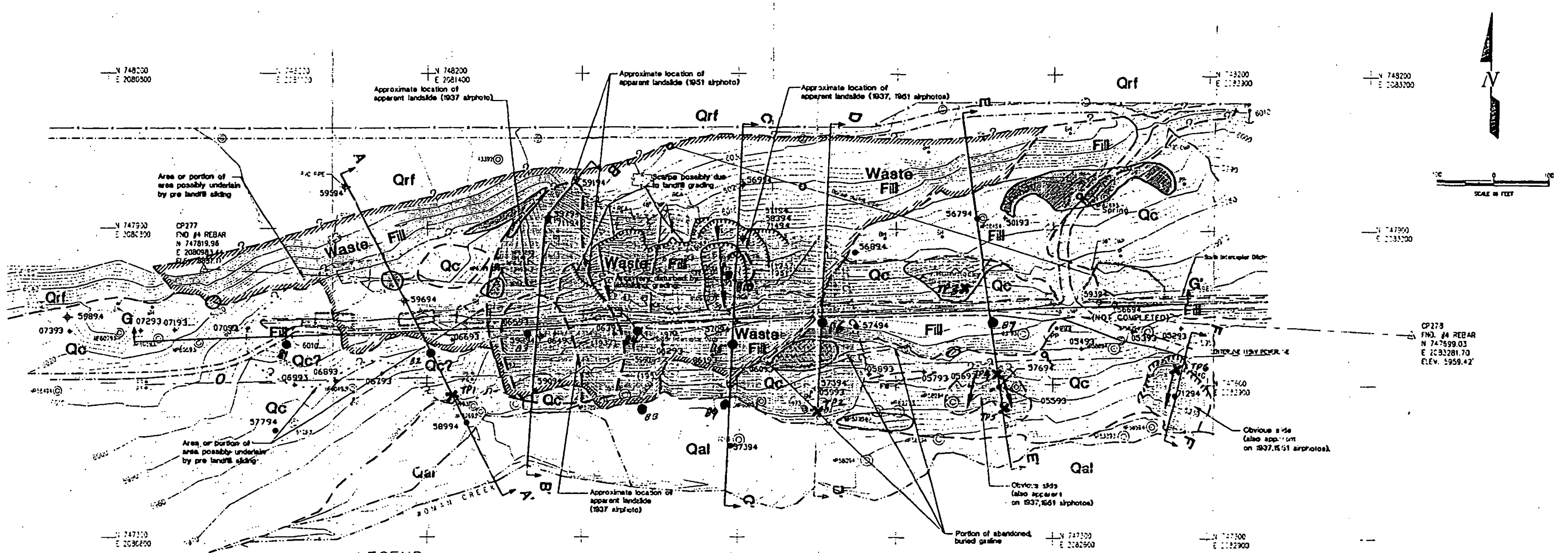
Geotechnical laboratory testing for Phase 2b work was performed by Advanced Terra Testing, Inc. All test data is provided in a separate volume to this memorandum.

Submitted to the Colorado Department of Public Health and Environment and the U.S. Environmental Protection Agency on September 9, 2004.

APPENDIX C

GEOLOGIC MAP AND CROSS SECTIONS

90



LEGEND

- Shallow groundwater area (indicated by thick, tall grass or other distinct vegetation).
- Spring
- Geologic contact, approximately located; dotted where concealed; queried where uncertain.
- (1937) Approximate outline of apparent landslide from pre-landfill airphoto, with year of photo in parentheses.
- Landslide area (some slide areas concealed by fill); based on examination of historic airphotos, field mapping and/or subsurface exploration; limits are approximately located, dotted where concealed, queried where uncertain. Arrow indicates discrete landslide with surface expression. See Note 1.
- Scarp (landslide-related unless noted otherwise).
- **Waste Fill** Sandy, Clayey Gravel and Cobbles (GC) derived from Qrf and Qc, and mixed with reflects historical production waste (wood, scrap metal, drums, graphite, concrete, etc.). Usually loose to medium dense; locally very loose. Inside edge of limits shown by
- **Fill** Road fill, other construction-related fill (e.g. for buried outfall pipe). Presumably clean (i.e., without admixed waste).
- **Qc** Colluvium : Sandy, Clayey Gravel and Cobbles (GC), and Sandy Clay (CL); finer Qc concentrated on lower slopes below South Interceptor Ditch. Generally medium dense (gravel), stiff to very stiff (clay). Locally less dense / softer.
- **Qal** Valley Fill Alluvium : Sandy, Silty-Clayey Gravel and Cobbles (GM, GC). Generally medium dense to dense.
- **Qrf** Rocky Flats Alluvium : Sandy, Clayey Gravel and Cobbles (GC). Generally dense. Includes local interbeds of stiff to hard clays and sandy clays (CL), and medium dense to very dense, fine, clean to clayey sands (SP, SC).
- 59694 Geotechnical Boring Installed with Shallow Well (in Fill, Qc, or Qrf)
- 59094 Geotechnical Boring, Backfilled
- 57194 Geotechnical Boring Installed with Bedrock Well
- 59894 Deep Monitoring Well (For Hydrogeologic Characterization)
- 07193 Cone Penetrometer Sounding (For Previous Hydrogeologic Characterization Work)
- G G' Geologic Section
- Surveyed Features on Base Topography Map Associated with Geologic Characterization Program

PHASE 2 - PROPOSED ADDITIONAL FIELD INVESTIGATION

•-Geotechnical Borehole

X-Backhoe Test Pit

Note:-Up to 2 additional boreholes assumed, adjacent to selected locations shown for additional sampling needs. B8 and B9 subject to acceptability for drilling at these locations. B8, B9, B10 subject to truck mounted drill rig accessibility.

NOTES:

1. Slide areas shown represent all areas with evidence of sliding documented during this investigation. Other areas of sliding possibly exist within the study area, below about El. 6020 and above Woman Creek; due to lack of surface expression, such areas would only be identifiable by further subsurface exploration.
2. See Figures 4 though 10 for geologic sections.
3. Operable unit 5 topography as of january 4, 1995.

From Harlan Fy 2004 Report 10/6/95

REV	DATE	DESCRIPTION	DR BY	APP BY

DES BY: F. HARLAN	PROJECT NO. 32242 — DATE MAY, 95
DRN BY: F. RIDENOUR	ROCKY FLATS ENVIRONMENTAL TECHNOLOGY SITE
CHK BY: F. HARLAN	OU-5 GEOTECHNICAL INVESTIGATION
ERV BY:	SHEET TITLE
CRV BY:	SITE GEOLOGIC MAP
APP BY: M. MOOERS	

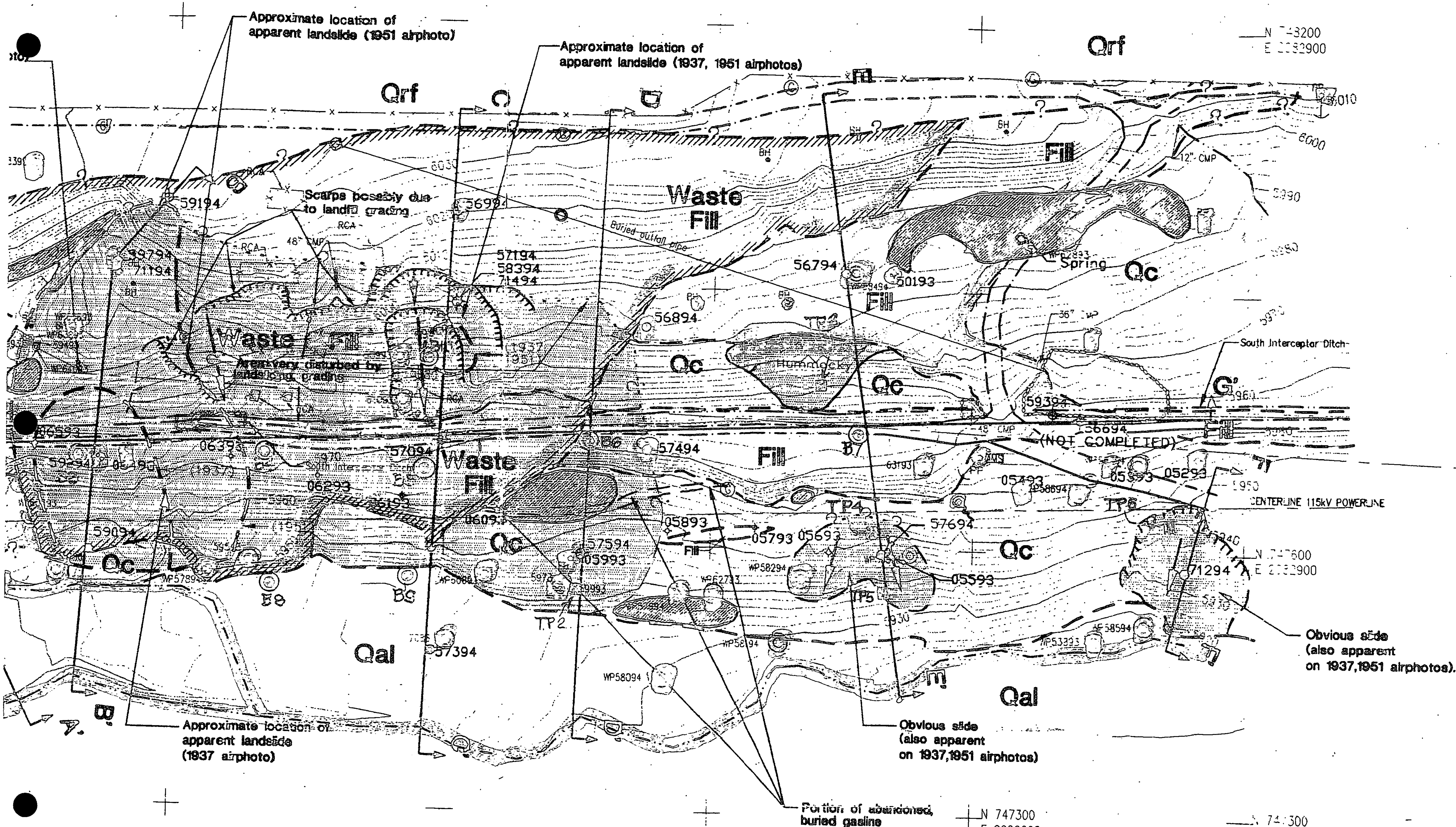
57278.6020
dn 3/11/01

DRAFT

SHEET NO.

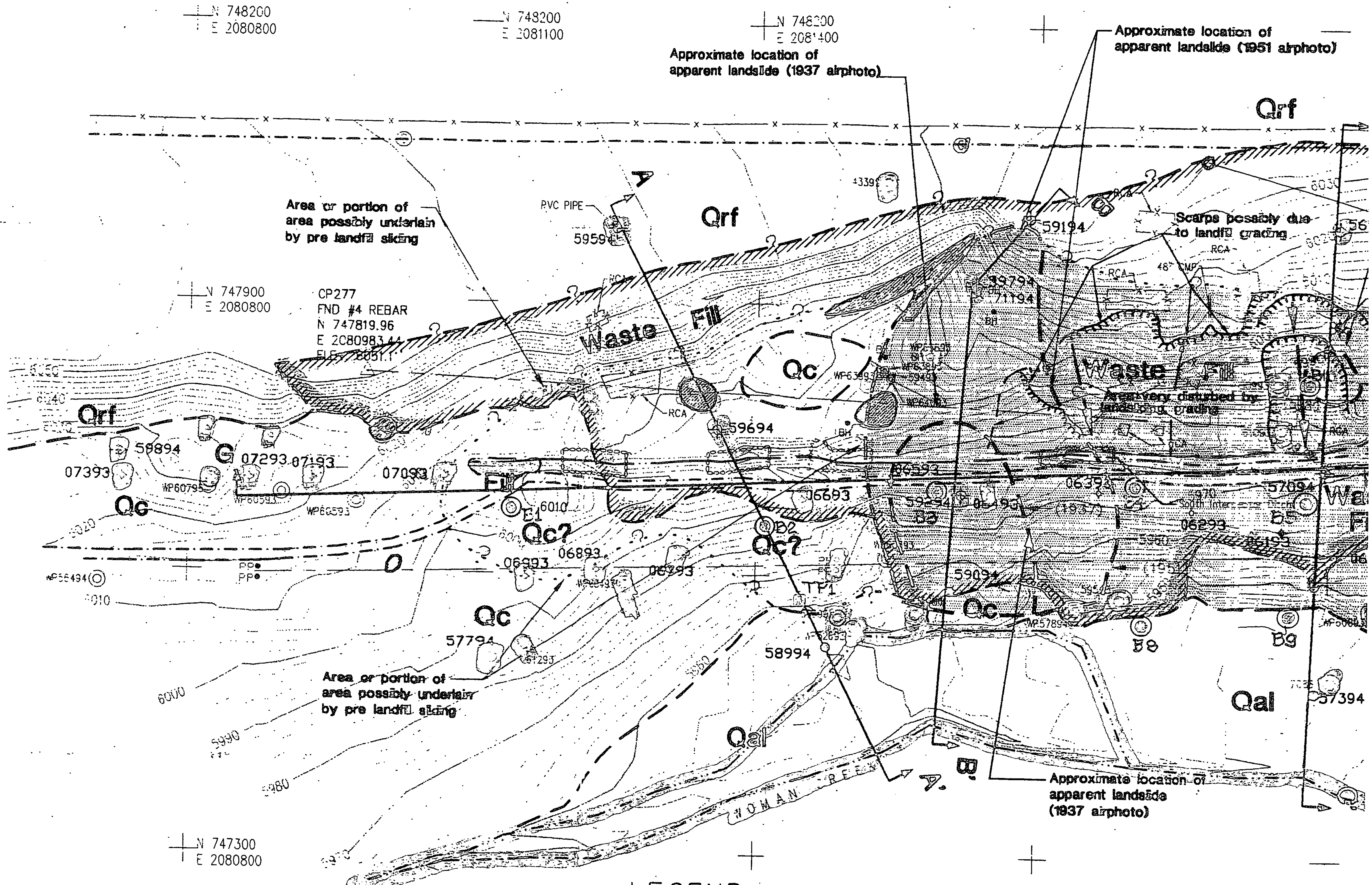
FIGURE 2

91



ndwater area (indicated by thick, tall grass or other distinct vegetation)

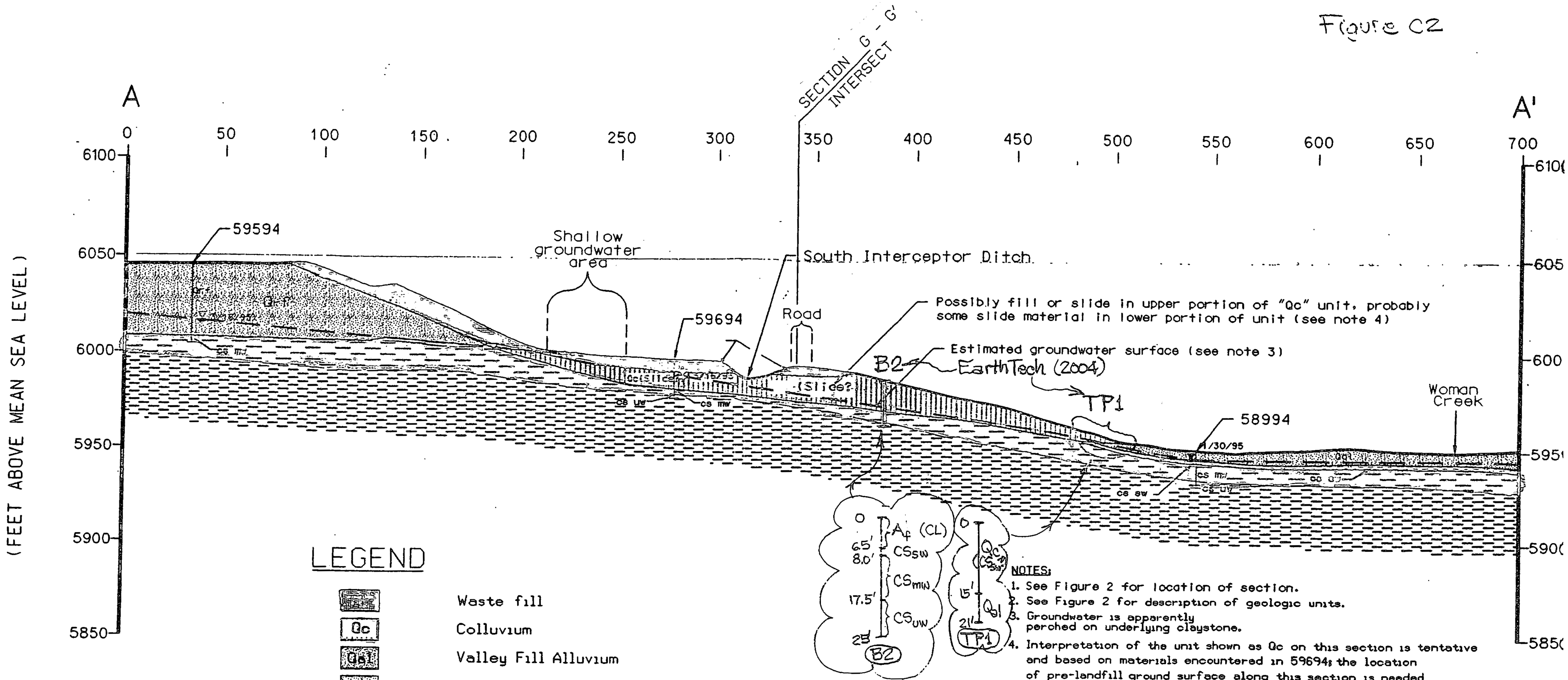
92


N 748200
E 2080800
N 748200
E 2081100
N 748200
E 2081400
Approximate location of
apparent landslide (1937 airphoto)
Approximate location of
apparent landslide (1951 airphoto)
Qrf
Area or portion of
area possibly underlain
by pre landfill siding
PVC PIPE
Scarps possibly due
to landfill grading
N 747900
E 2080800
CP277
FND #4 REBAR
N 747819.96
E 2080983.44
Waste Fill
Qc
Area very disturbed by
landfill grading
RCA
59194
59694
59894
07393
07293
07193
07093
Fill
E1
Qc?
06993
06893
06293
06693
06393
57094
06293
06193
59094
58994
57794
Area or portion of
area possibly underlain
by pre landfill siding
Qal
B8
B9
57394
Approximate location of
apparent landslide
(1937 airphoto)
TP1
N 747300
E 2080800

LEGEND

93

Figure C2



LEGEND

Waste fill	
Qc	Colluvium
Qal	Valley Fill Alluvium
Qrf	Rocky Flats Alluvium
CS	Laramie Formation Claystone:
sw	severely weathered
mw	moderately weathered
uw	unweathered

59694
Qc ▽ 3/16/95
cs mw

Geotechnical boring, backfilled or with monitoring well, showing geologic units, groundwater elevation and date measured.

NOTES:

1. See Figure 2 for location of section.
2. See Figure 2 for description of geologic units.
3. Groundwater is apparently perched on underlying claystone.
4. Interpretation of the unit shown as Qc on this section is tentative and based on materials encountered in 59694; the location of pre-landfill ground surface along this section is needed to more confidently interpret origin of these materials.

50 0 50

SCALE IN FEET

DRAFT

PROJECT #:	32242
ORIG. DATE:	MAY, 1995
PREP. BY:	R. RIDENOUR
REV. BY:	R. HARLAN
SCALE:	1" = 50'
FILE NAME:	N:*...*ROCKY*AA.DGN

Prepared for:

U.S. DEPARTMENT OF ENERGY
ROCKY FLATS ENVIRONMENTAL
TECHNOLOGY SITE, GOLDEN COLO

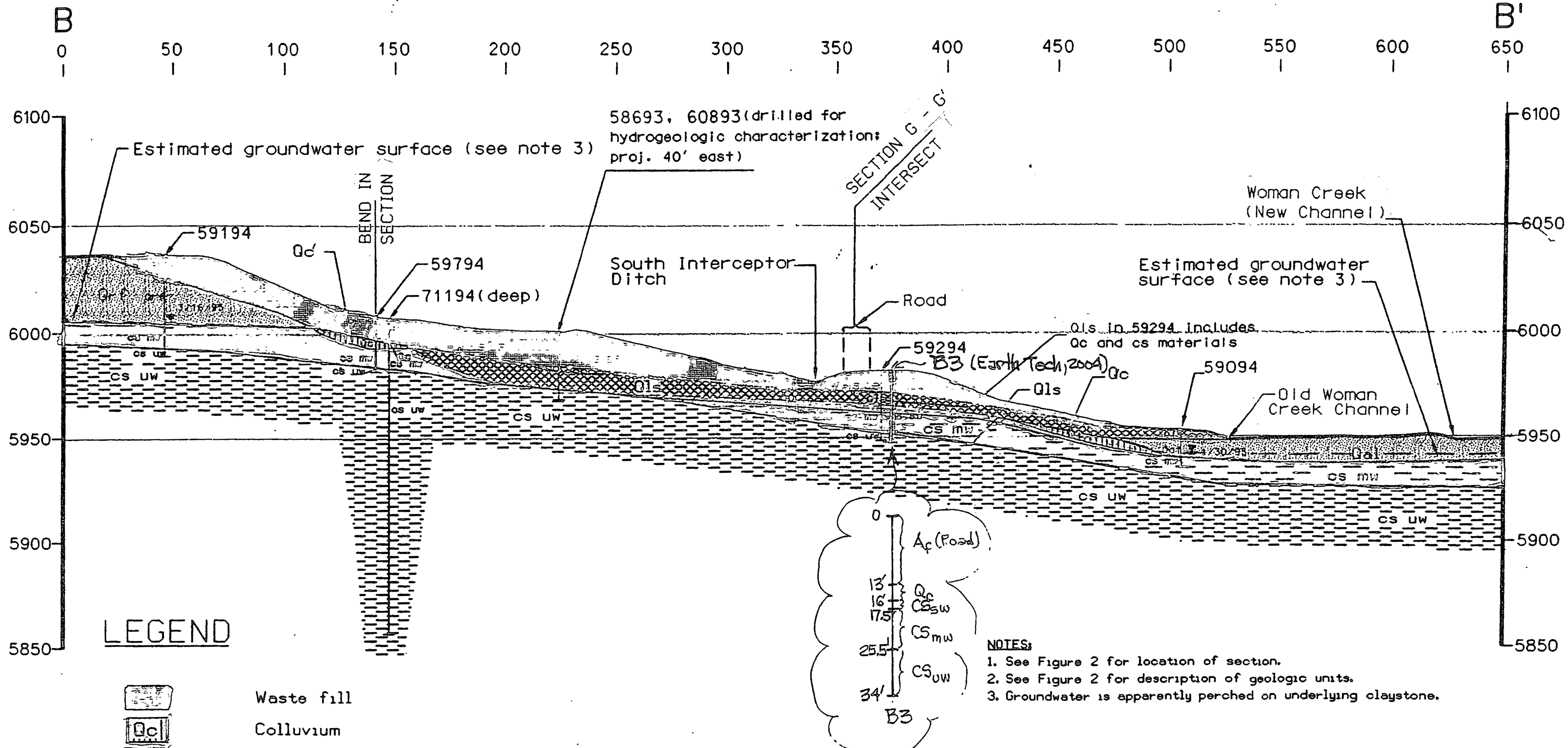
PREPDATE: SEPTEMBER 1995

FIGURE 4

OU-5 GEOTECHNICAL INVESTIG
SECTION A-A'

2app\ustation\out\dgn\aa.dg Sep. 27, 1995 15:22:56

Figure C3



LEGEND

	Waste fill
Qc	Colluvium
Qls	Landslide Deposits (unit may contain material from several discrete landslides).
Qal	Valley Fill Alluvium
Qrf	Rocky Flats Alluvium
cs	Laramie Formation Claystone:
sw	severely weathered
mw	moderately weathered
uw	unweathered

59194
Qrf
3/16/95
cs mw

Geotechnical boring, backfilled or with monitoring well, showing geologic units, groundwater elevation and date measured.

NOTES:
1. See Figure 2 for location of section.
2. See Figure 2 for description of geologic units.
3. Groundwater is apparently perched on underlying claystone.

50 0 50
SCALE IN FEET

DRAFT

PROJECT #:	32242
ORIG. DATE:	MAY, 1995
PREP. BY:	R. RIDENOUR
REV. BY:	R. HARLAN
SCALE:	1" = 50'

Prepared for:
U.S. DEPARTMENT OF ENERGY
ROCKY FLATS ENVIRONMENTAL TECHNOLOGY SITE, GOLDEN COLORADO

PREPDATE: SEPTEMBER 1995

FIGURE 5
OU-5 GEOTECHNICAL INVESTIGATION
SECTION B-B'

95

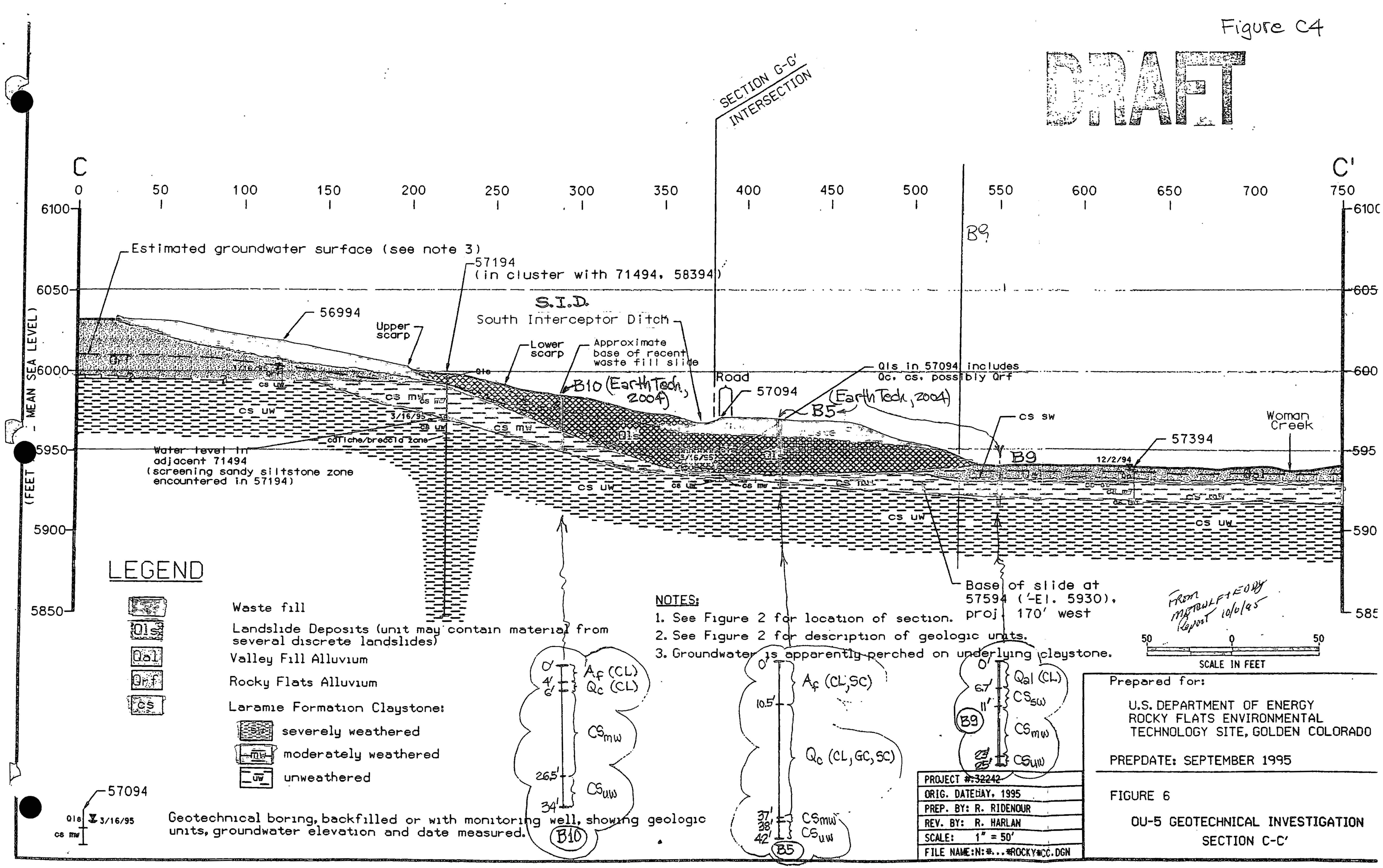
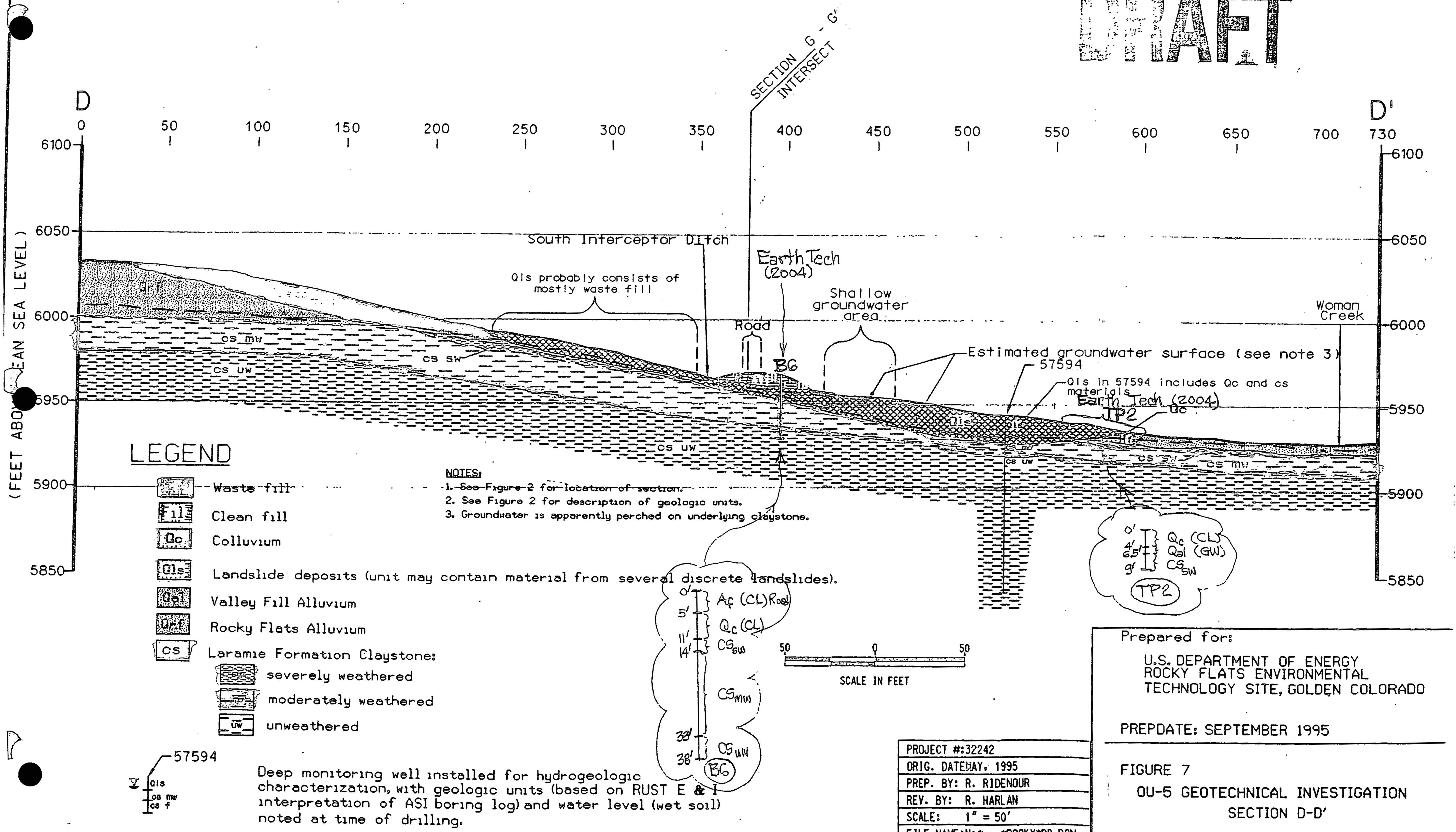


Figure C4
DRAFT
SECTION G-G' INTERSECTION
C
C'
0
50
100
150
200
250
300
350
400
450
500
550
600
650
700
750
6100
6050
6000
5950
5900
5850
(FEET - MEAN SEA LEVEL)
B9
Estimated groundwater surface (see note 3)
57194
(in cluster with 71494, 58394)
56994
Upper scarp
S.I.D.
South Interceptor Ditch
Lower scarp
Approximate base of recent waste fill slide
B10 (Earth Tech, 2004)
Road
57094
Qls in 57094 includes Qc, cs, possibly Qrf
(Earth Tech, 2004)
B5
cs sw
Woman Creek
57394
12/2/94
cs uw
cs mw
3/16/95
caliche/breccia zone
Water level in adjacent 71494 (screening sandy siltstone zone encountered in 57194)
Qls
cs uw
cs uw
cs uw
Base of slide at 57594 (~El. 5930), proj. 170' west
LEGEND
Waste fill
Landslide Deposits (unit may contain material from several discrete landslides)
Valley Fill Alluvium
Rocky Flats Alluvium
Laramie Formation Claystone:
severely weathered
moderately weathered
unweathered
57094
Qls
3/16/95
cs mw
Geotechnical boring, backfilled or with monitoring well, showing geologic units, groundwater elevation and date measured.
NOTES:
1. See Figure 2 for location of section.
2. See Figure 2 for description of geologic units.
3. Groundwater is apparently perched on underlying claystone.
0'
4'
6'
Af (CL)
Qc (CL)
CSmw
26.5'
CSuw
34'
B10
0'
Af (CL,SC)
10.5'
Qc (CL, GC, SC)
37'
38'
42'
CSmw
CSuw
B5
0'
Qal (CL)
6.7'
CSsw
11'
B9
CSmw
23'
25'
CSuw
From Metcalf + Eddy Report 10/6/95
50
0
50
SCALE IN FEET
PROJECT #:32242
ORIG. DATE:MAY, 1995
PREP. BY: R. RIDENOUR
REV. BY: R. HARLAN
SCALE: 1" = 50'
FILE NAME:N:\...\ROCKY\CC.DGN
Prepared for:
U.S. DEPARTMENT OF ENERGY
ROCKY FLATS ENVIRONMENTAL TECHNOLOGY SITE, GOLDEN COLORADO
PREPDATE: SEPTEMBER 1995
FIGURE 6
OU-5 GEOTECHNICAL INVESTIGATION
SECTION C-C'

Figure C5

DRAFT



Prepared for:

U.S. DEPARTMENT OF ENERGY
ROCKY FLATS ENVIRONMENTAL TECHNOLOGY SITE, GOLDEN COLORADO

PREPDATE: SEPTEMBER 1995

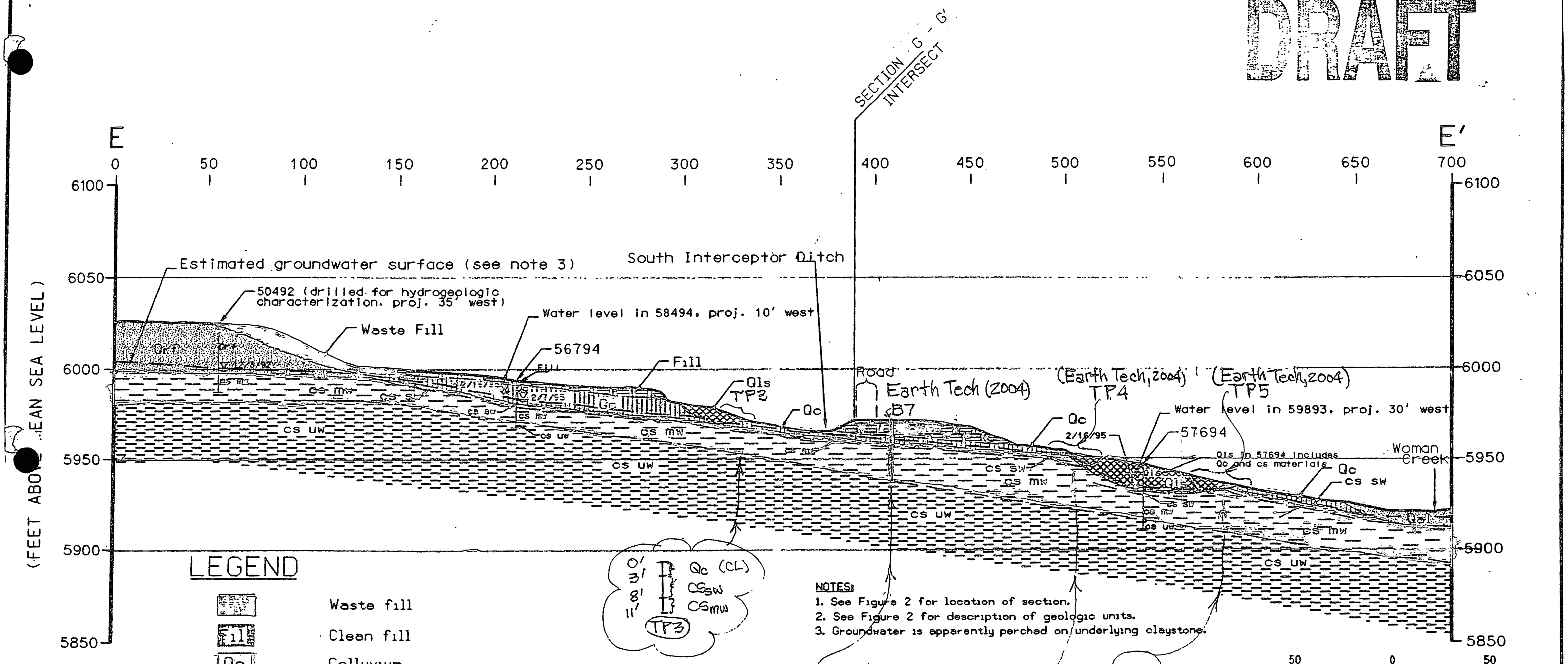
PROJECT #:	32242
ORIG. DATE:	MAY, 1995
PREP. BY:	R. RIDENOUR
REV. BY:	R. HARLAN
SCALE:	1" = 50'
FILE NAME:	N:*...*ROCKY*DD.DGN

FIGURE 7

OU-5 GEOTECHNICAL INVESTIGATION
SECTION D-D'

Figure C6

DRAFT



LEGEND

- Waste fill
- Clean fill
- Colluvium (Qc)
- Landslide Deposits (unit may contain material from several discrete landslides) (Qls)
- Valley Fill Alluvium (Qal)
- Rocky Flats Alluvium (Qrf)
- Laramie Formation Claystone: (cs)
  - severely weathered
  - moderately weathered
  - unweathered

57694 — 3/16/95 — Qls, cs sw, cs mw, cs f

Geotechnical boring, backfilled, showing geologic units, groundwater elevation and date encountered.

NOTES:
1. See Figure 2 for location of section.
2. See Figure 2 for description of geologic units.
3. Groundwater is apparently perched on underlying claystone.

50 0 50
SCALE IN FEET

PROJECT #:	32242
ORIG. DATE:	MAY, 1995
PREP. BY:	R. RIDENOUR
REV. BY:	R. HARLAN
SCALE:	1" = 50'
FILE NAME:	N:*...*ROCKY*EE.DGN

Prepared for:

U.S. DEPARTMENT OF ENERGY
ROCKY FLATS ENVIRONMENTAL TECHNOLOGY SITE, GOLDEN COLORADO

PREPDATE: SEPTEMBER 1995

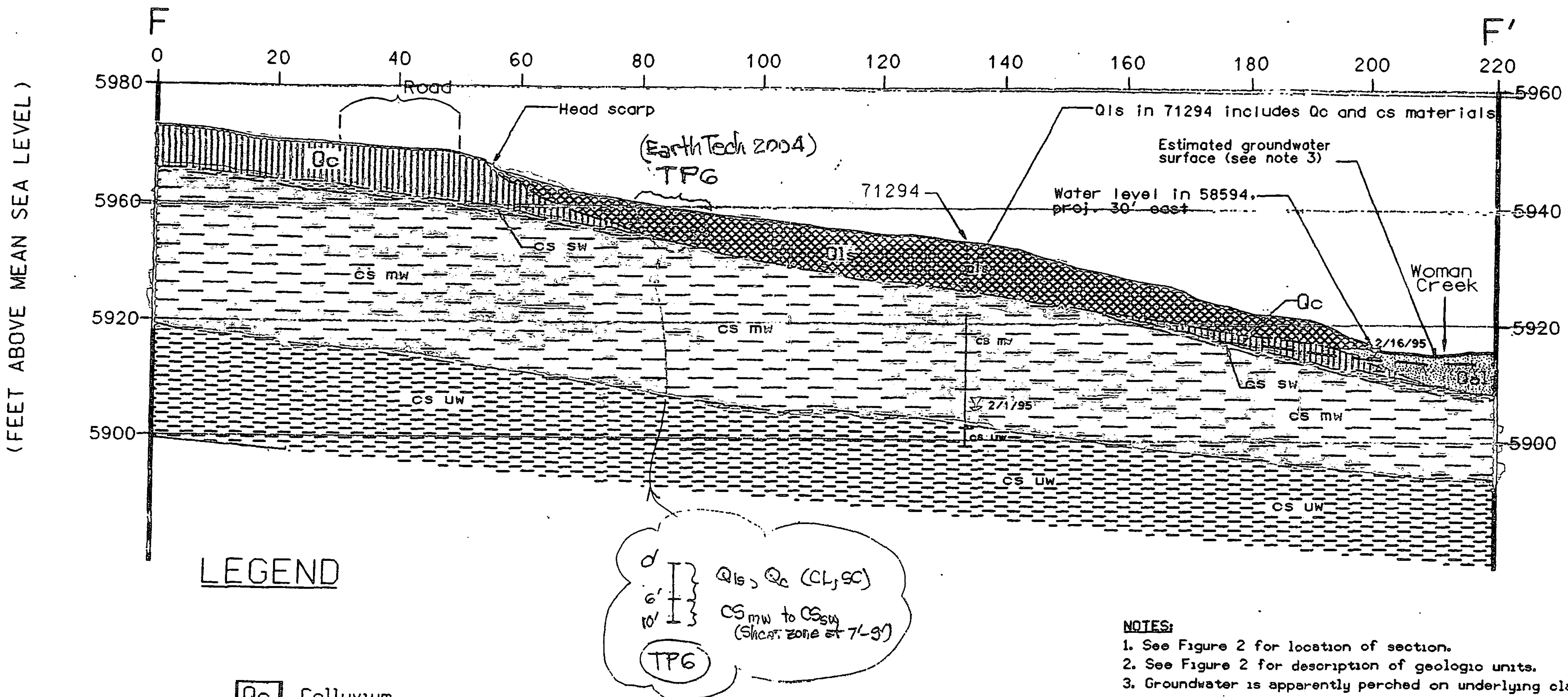
FIGURE 8

OU-5 GEOTECHNICAL INVESTIGATION

SECTION E-E'

Figure C7

DRAFT



LEGEND

- Qc — Colluvium
- Qls — Landslide Deposits (unit may contain material from several discrete landslides)
- Qal — Valley Fill Alluvium
- cs — Laramie Formation Claystone:
  - sw — severely weathered
  - mw — moderately weathered
  - uw — unweathered

71294 (Qls, cs mw, cs f; 2/1/95) — Geotechnical boring, backfilled, showing geologic units, groundwater elevation and date encountered.

NOTES:
1. See Figure 2 for location of section.
2. See Figure 2 for description of geologic units.
3. Groundwater is apparently perched on underlying claystone.

20 0 20
SCALE IN FEET

PROJECT #:32242
ORIG. DATE:MAY, 1995
PREP. BY: R. RIDENOUR
REV. BY: R. HARLAN
SCALE: 1" = 50'
FILE NAME:N:*...*ROCKY*AA.DGN

Prepared for:

U.S. DEPARTMENT OF ENERGY
ROCKY FLATS ENVIRONMENTAL TECHNOLOGY SITE, GOLDEN COLORADO

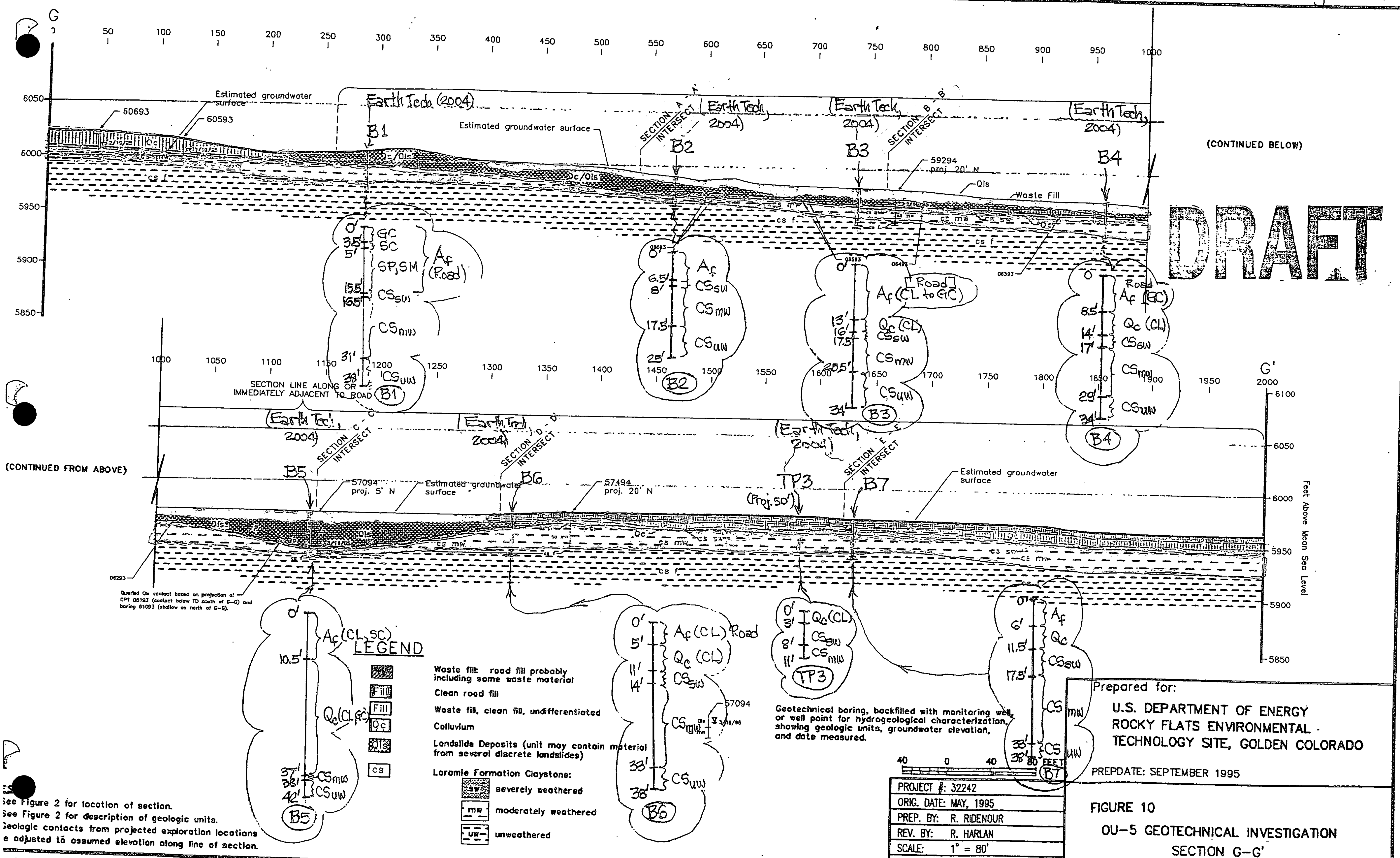
PREPDATE: SEPTEMBER 1995

FIGURE 9

OU-5 GEOTECHNICAL INVESTIGATION

SECTION F-F'

Figure C8



NOTES:
See Figure 2 for location of section.
See Figure 2 for description of geologic units.
Geologic contacts from projected exploration locations are adjusted to assumed elevation along line of section.

PROJECT #:	32242
ORIG. DATE:	MAY, 1995
PREP. BY:	R. RIDENOUR
REV. BY:	R. HARLAN
SCALE:	1" = 80'
FILE NAME:	j:\...\rckyflats\g1g1.dwg

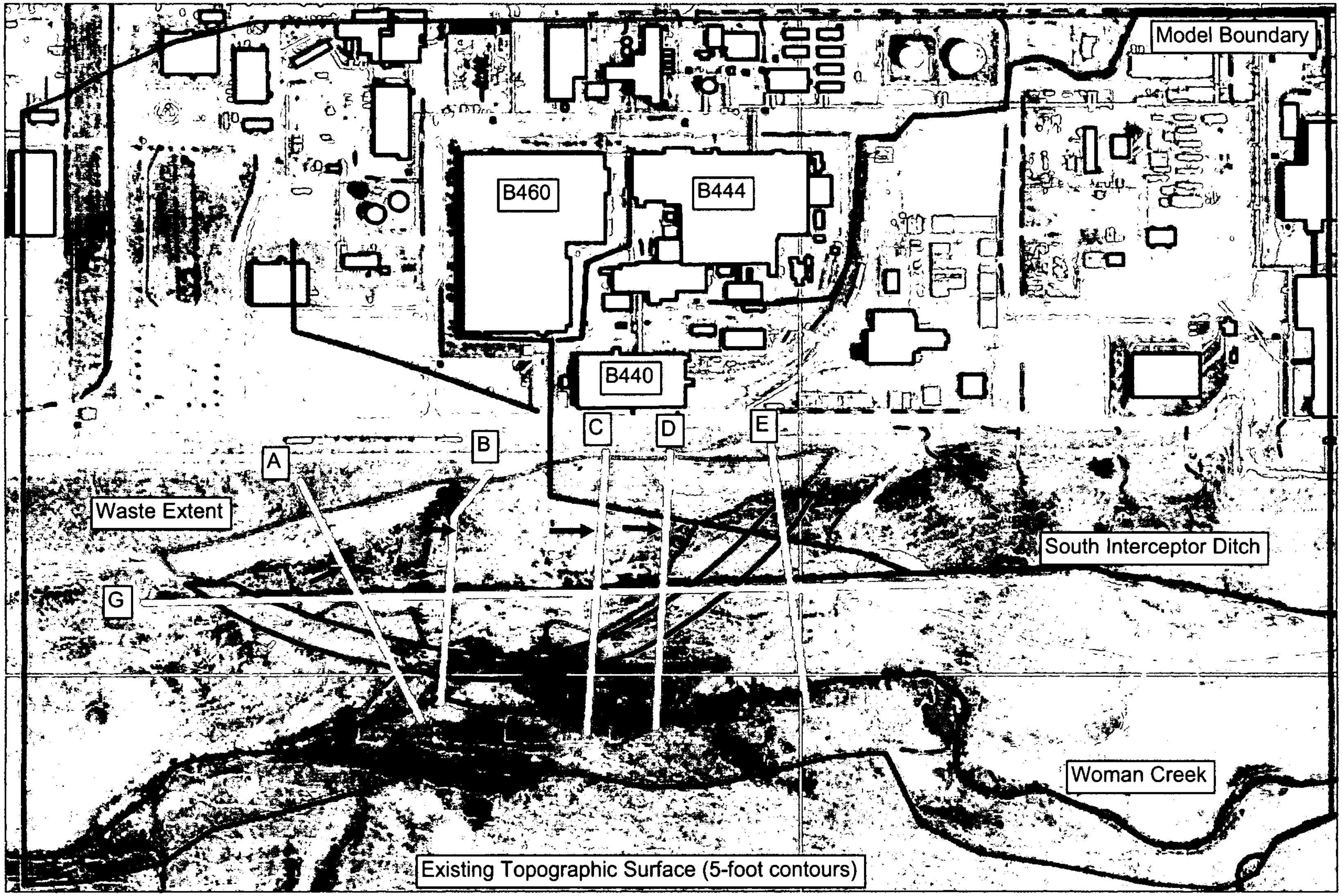
Prepared for:
U.S. DEPARTMENT OF ENERGY
ROCKY FLATS ENVIRONMENTAL TECHNOLOGY SITE, GOLDEN COLORADO

PREPDATE: SEPTEMBER 1995

FIGURE 10
OU-5 GEOTECHNICAL INVESTIGATION
SECTION G-G'

100

102



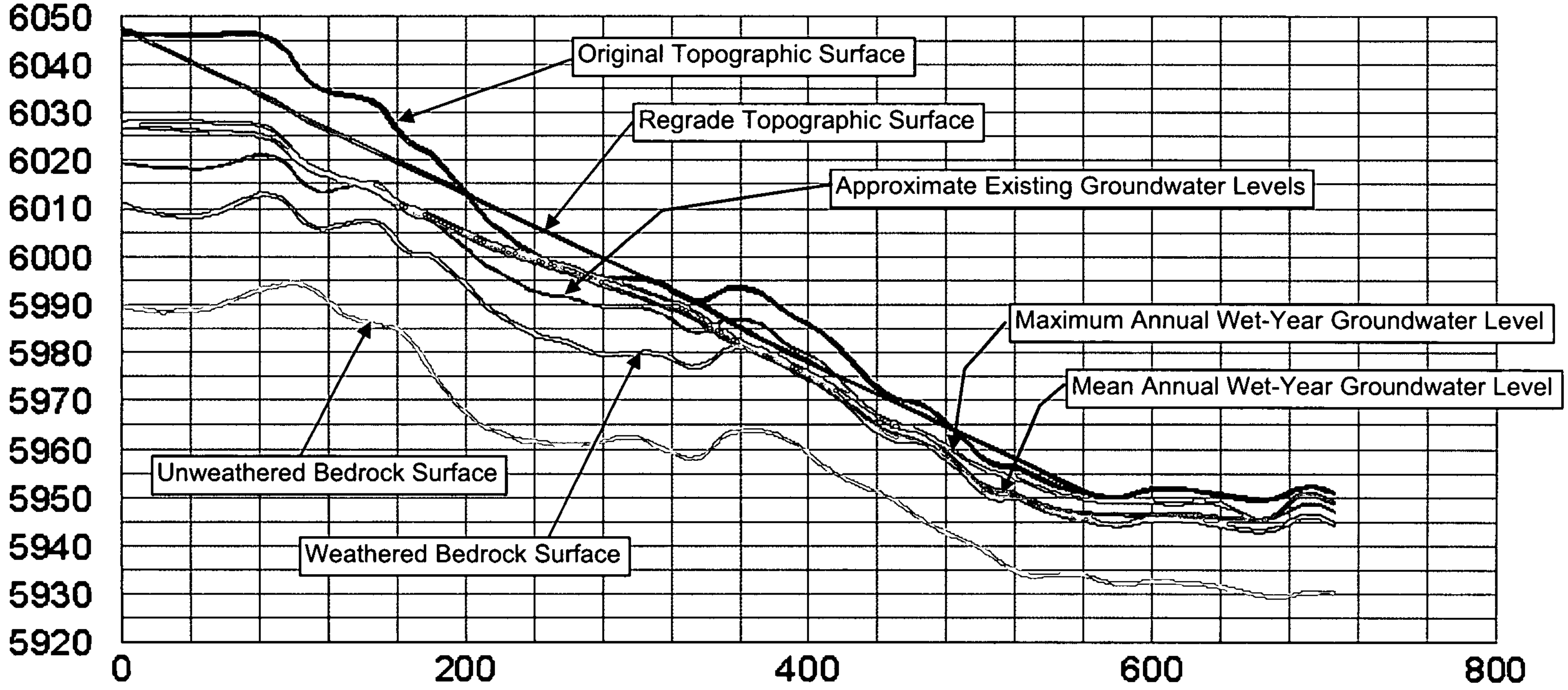
NOTE:

A Vertical Profile Location - Initially defined in Metcalf & Eddy Report (9/1995)

Profile View Direction

Integrated Hydro Systems, LLC

OLF study area, waste extent, current surface topography, and vertical profile locations.

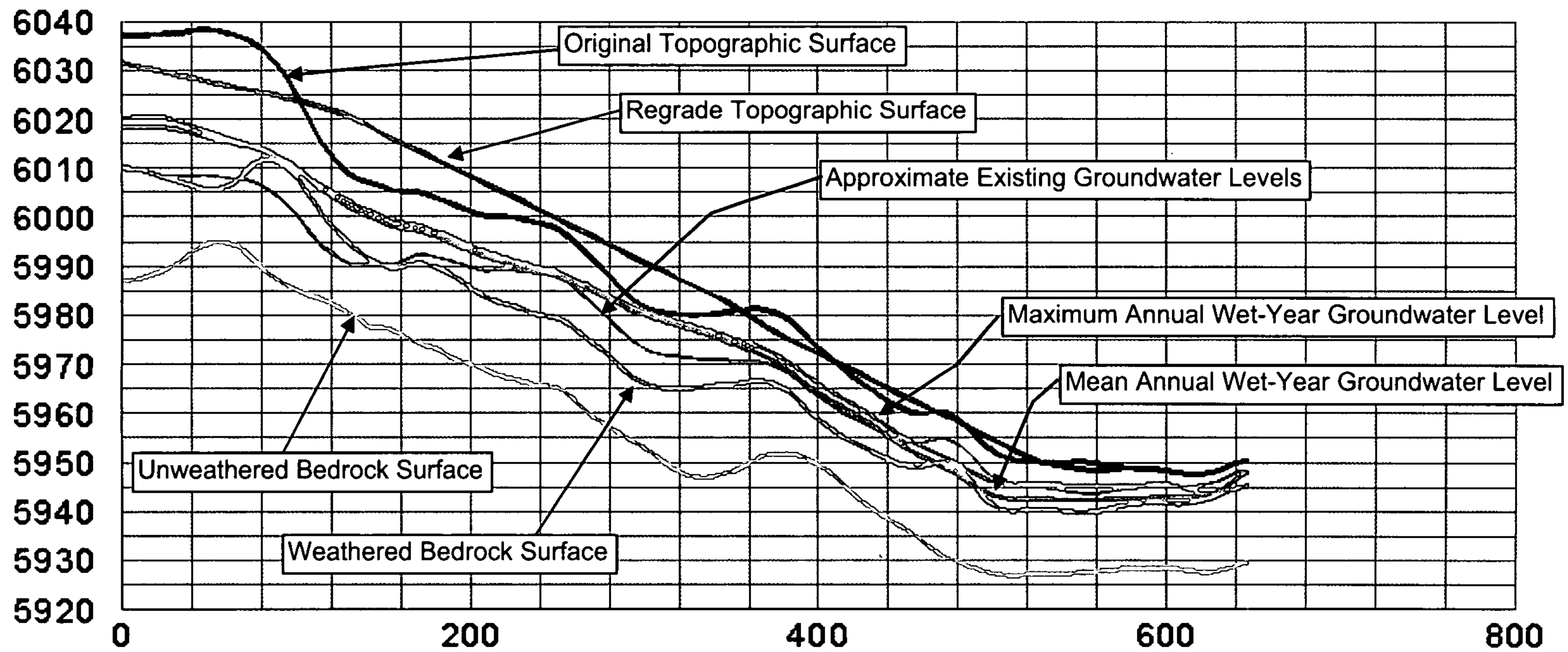


NOTES:
1) Horizontal and Vertical Units are feet
2) Vertical exaggeration is 3x
3) Wet Year water levels based on 100-year climate sequence (see OLF groundwater tech report for details).

Integrated Hydro Systems, LLC

Vertical Profile A
Geologic Surfaces and Groundwater Levels

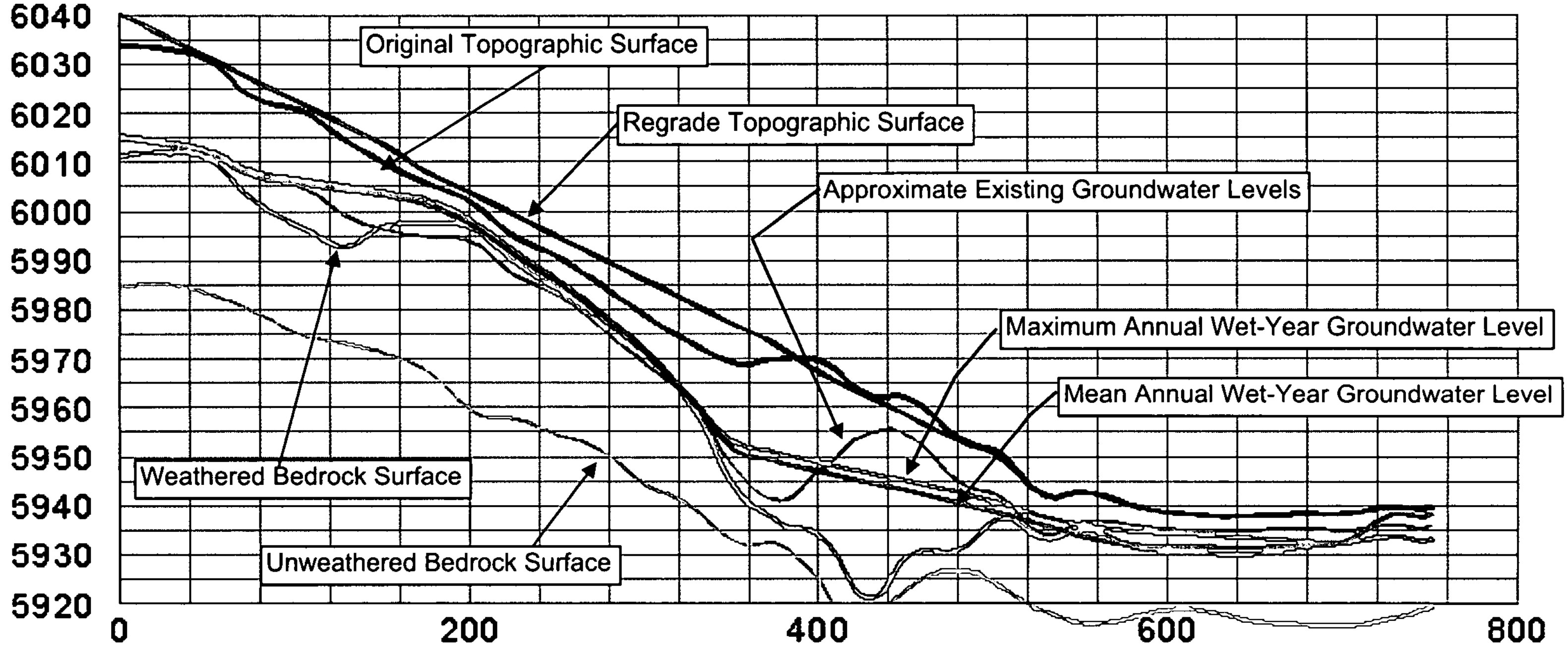
102



NOTES:
1) Horizontal and Vertical Units are feet
2) Vertical exaggeration is 3x
3) Wet Year water levels based on 100-year climate sequence (see OLF groundwater tech report for details).

Integrated Hydro Systems, LLC

Vertical Profile B
Geologic Surfaces and Groundwater Levels

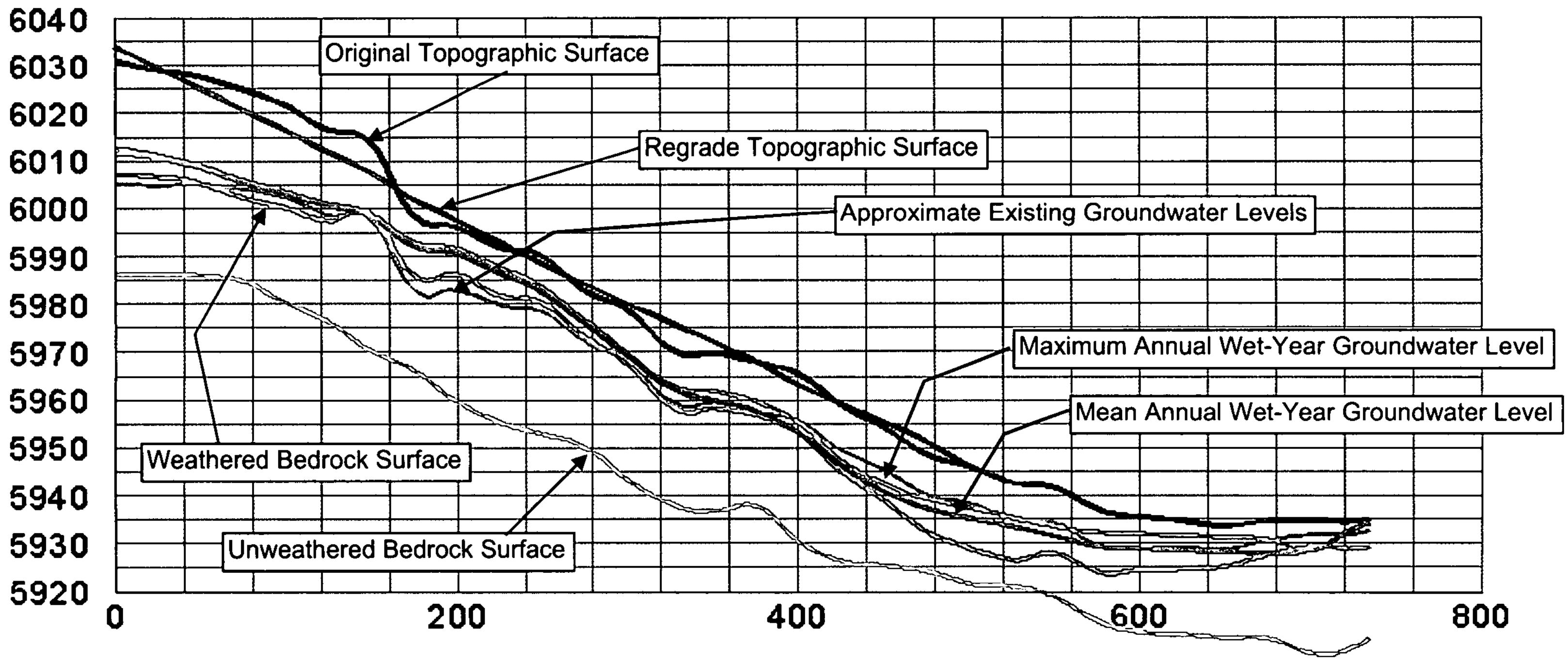


NOTES:
1) Horizontal and Vertical Units are feet
2) Vertical exaggeration is 3x
3) Wet Year water levels based on 100-year climate sequence (see OLF groundwater tech report for details).

Integrated Hydro Systems, LLC

Vertical Profile C
Geologic Surfaces and Groundwater Levels

106



NOTES:
1) Horizontal and Vertical Units are feet
2) Vertical exaggeration is 3x
3) Wet Year water levels based on 100-year climate sequence (see OLF groundwater tech report for details).

Integrated Hydro Systems, LLC

Vertical Profile D
Geologic Surfaces and Groundwater Levels

APPENDIX E

STABILITY ANALYSES

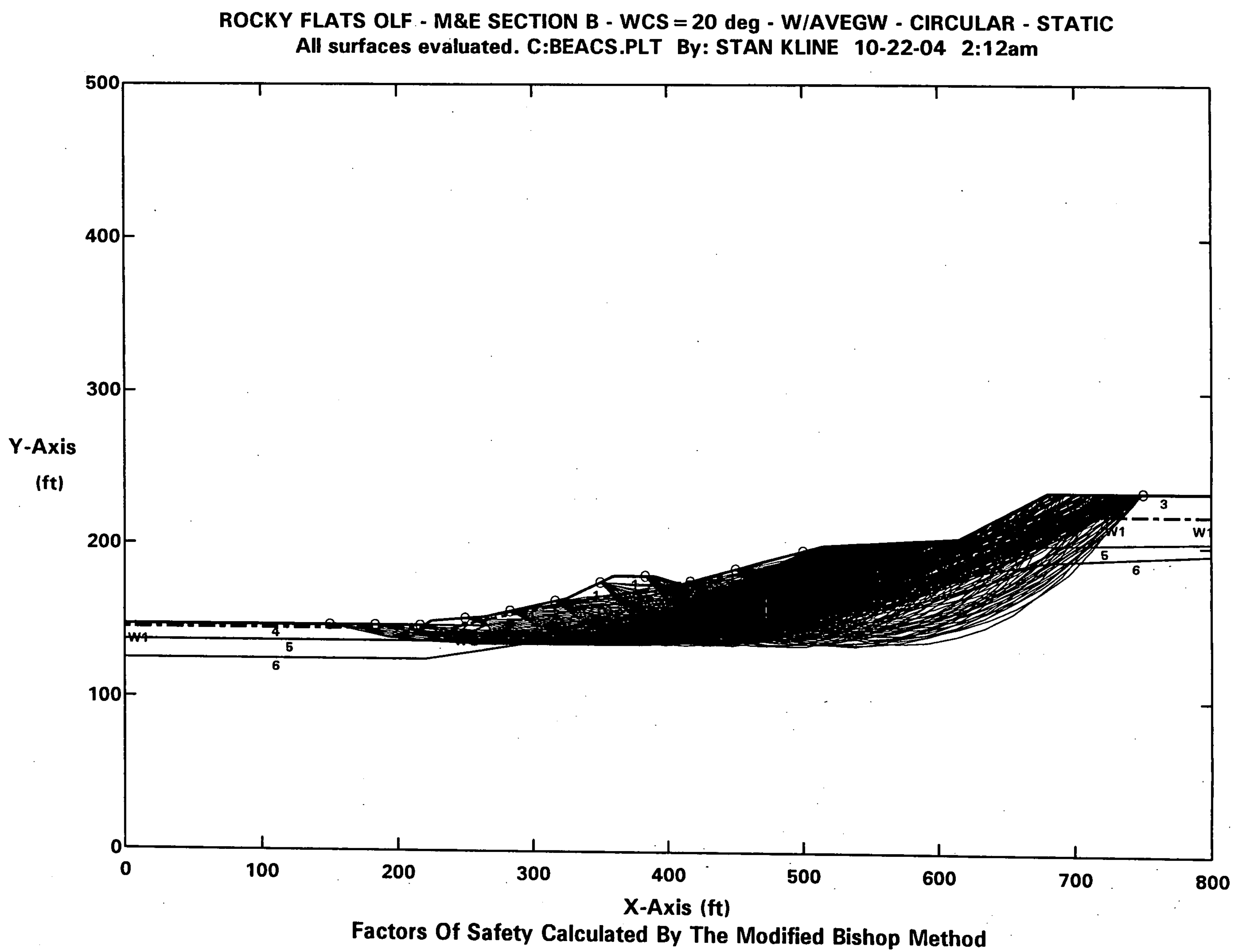
107

M&E SECTION B-B' – STATIC

10

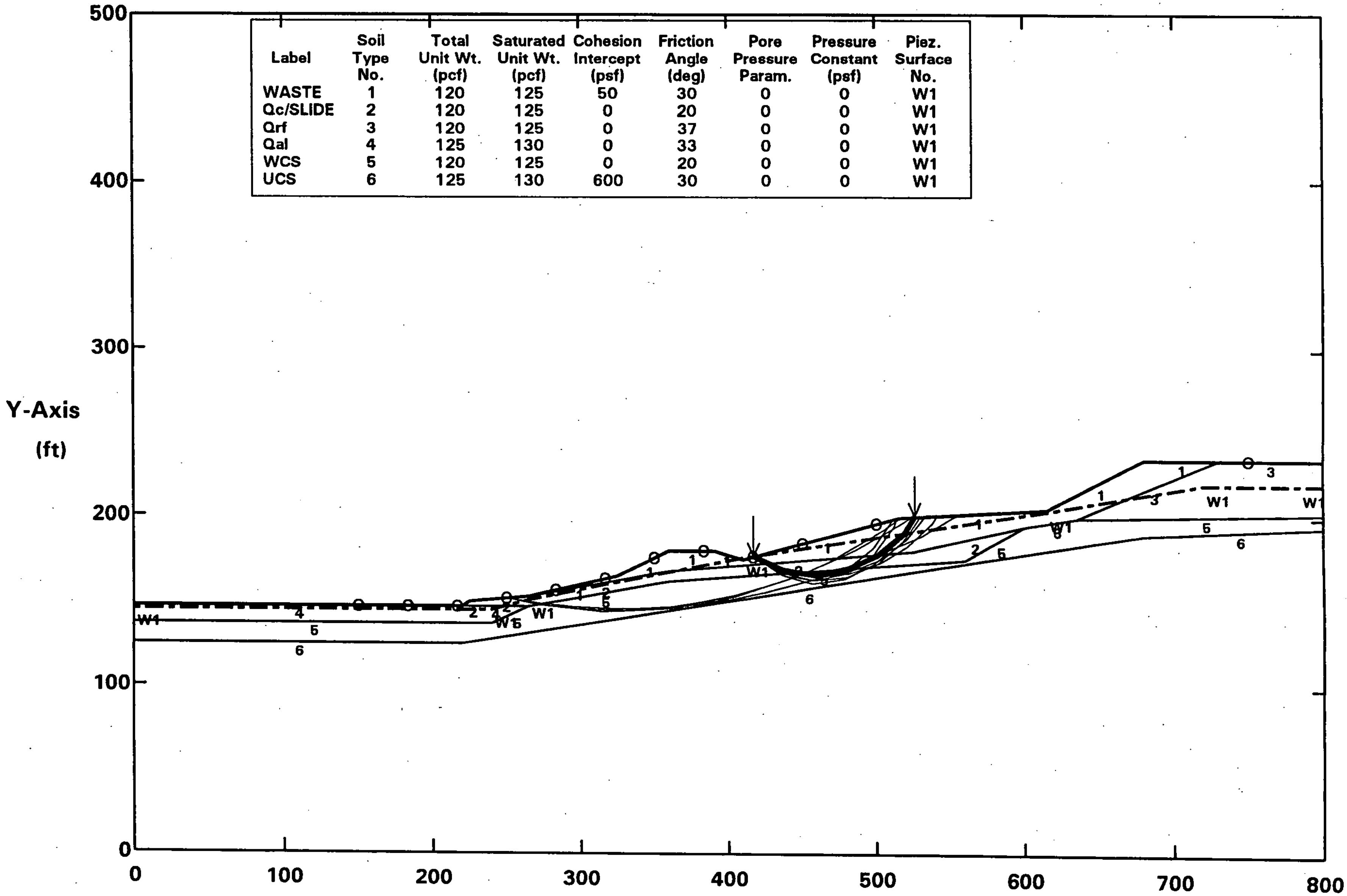
EXISTING CONDITIONS

109


ROCKY FLATS OLF - M&E SECTION B - WCS = 20 deg - W/AVEGW - CIRCULAR - STATIC
All surfaces evaluated. C:BEACS.PLT By: STAN KLINE 10-22-04 2:12am
500
400
300
200
100
0
Y-Axis
(ft)
0
100
200
300
400
500
600
700
800
X-Axis (ft)
W1
4
5
6
3
Factors Of Safety Calculated By The Modified Bishop Method

ROCKY FLATS OLF - M&E SECTION B - WCS = 20 deg - W/AVEGW - CIRCULAR - STATIC
Ten Most Critical. C:BEACS.PLT By: STAN KLINE 10-22-04 2:12am

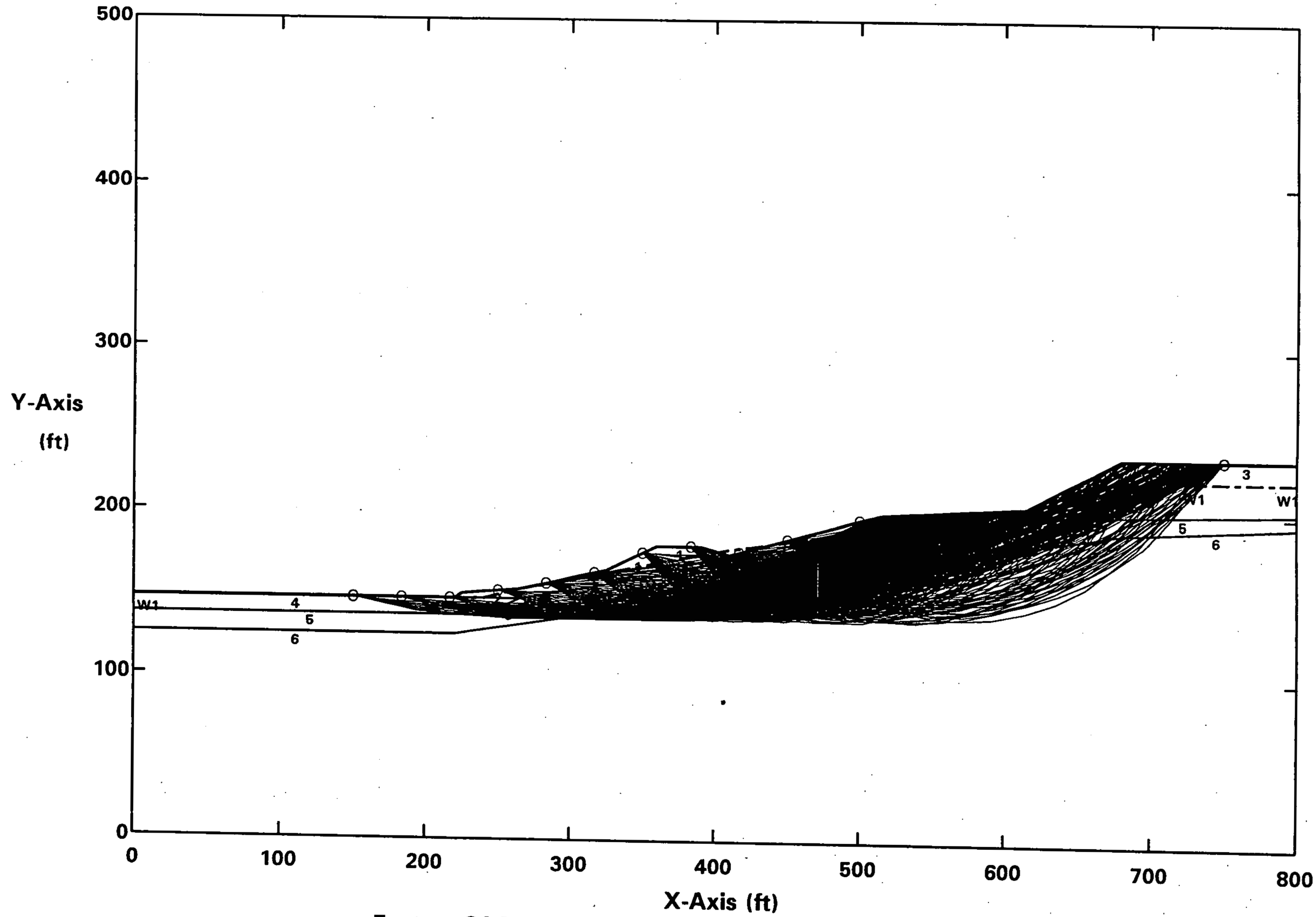
Label	Soil Type No.	Total Unit Wt. (pcf)	Saturated Unit Wt. (pcf)	Cohesion Intercept (psf)	Friction Angle (deg)	Pore Pressure Param.	Pressure Constant (psf)	Piez. Surface No.
WASTE	1	120	125	50	30	0	0	W1
Qc/SLIDE	2	120	125	0	20	0	0	W1
Qrf	3	120	125	0	37	0	0	W1
Qal	4	125	130	0	33	0	0	W1
WCS	5	120	125	0	20	0	0	W1
UCS	6	125	130	600	30	0	0	W1



PCSTABL5M/SI FSmin = 1.49 X-Axis (ft)
Factors Of Safety Calculated By The Modified Bishop Method

112

ROCKY FLATS OLF - M&E SECTION B - WCS=20 deg - W/HIGHGW - CIRCULAR - STATIC
All surfaces evaluated. C:BEHCS.PLT By: STAN KLINE 10-23-04 6:56pm

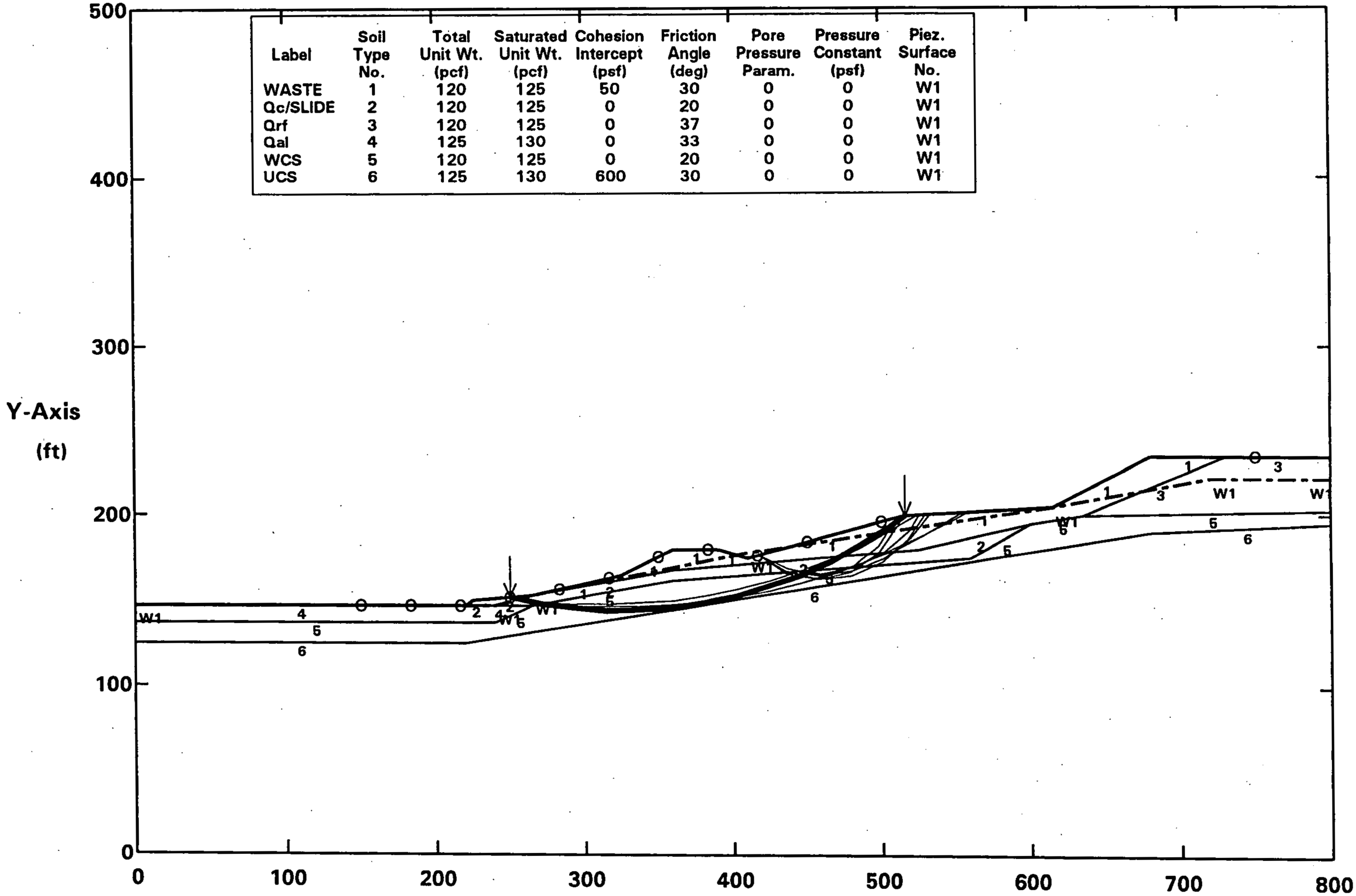


Factors Of Safety Calculated By The Modified Bishop Method

13

ROCKY FLATS OLF - M&E SECTION B - WCS = 20 deg - W/HIGHGW - CIRCULAR - STATIC
Ten Most Critical. C:BEHCS.PLT By: STAN KLINE 10-23-04 6:56pm

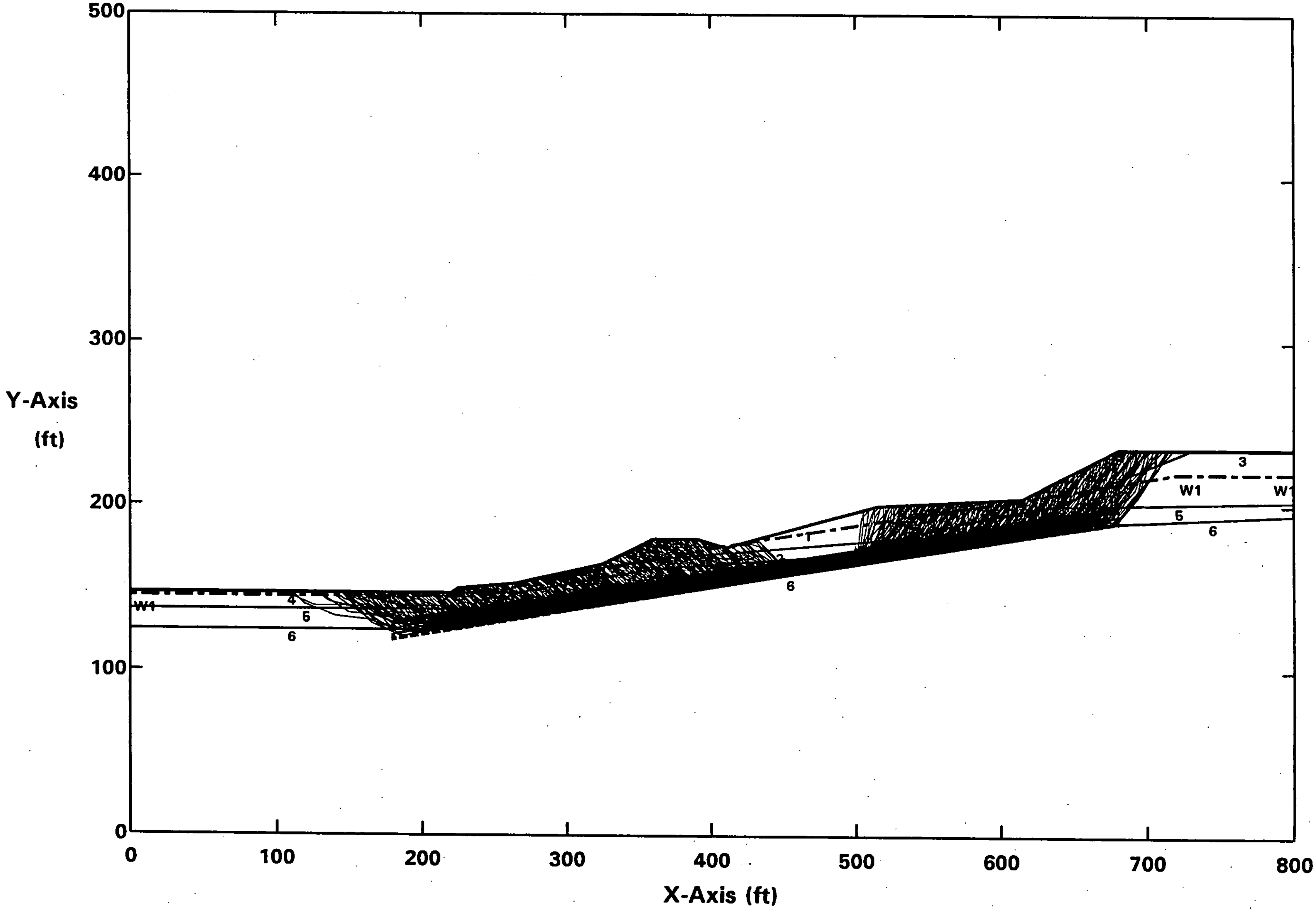
Label	Soil Type No.	Total Unit Wt. (pcf)	Saturated Unit Wt. (pcf)	Cohesion Intercept (psf)	Friction Angle (deg)	Pore Pressure Param.	Pressure Constant (psf)	Piez. Surface No.
WASTE	1	120	125	50	30	0	0	W1
Qc/SLIDE	2	120	125	0	20	0	0	W1
Qrf	3	120	125	0	37	0	0	W1
Qal	4	125	130	0	33	0	0	W1
WCS	5	120	125	0	20	0	0	W1
UCS	6	125	130	600	30	0	0	W1



PCSTABL5M/SI FSmin = 1.40 X-Axis (ft)
Factors Of Safety Calculated By The Modified Bishop Method

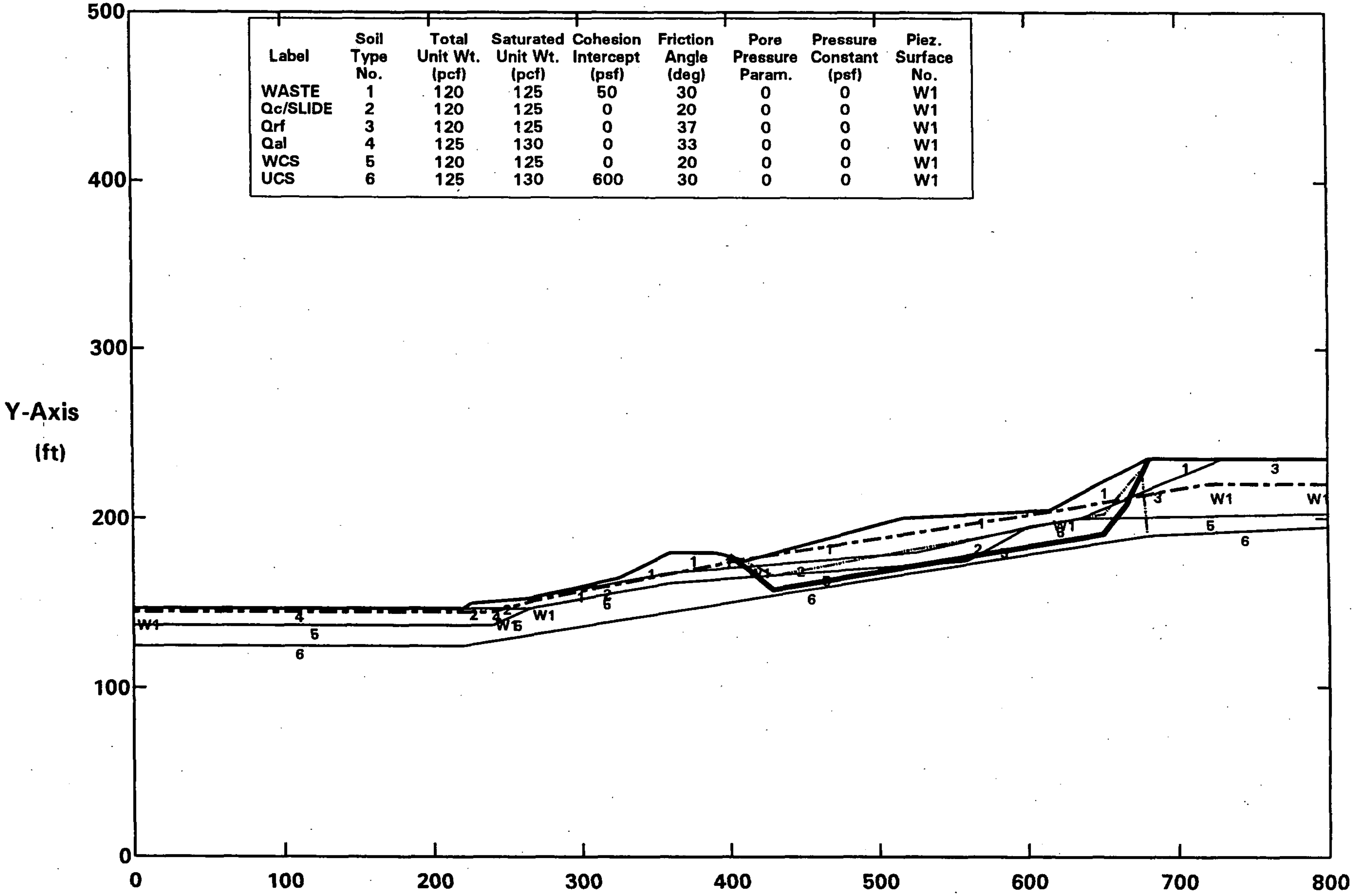
114

ROCKY FLATS OLF - M&E SECTION B - WCS=20 deg - W/AVEGW - SLIDING BLOCK - STATIC
All surfaces evaluated. C:BEASS.PLT By: STAN KLINE 10-22-04 1:53am



Factors Of Safety Calculated By The Modified Janbu Method

ROCKY FLATS OLF - M&E SECTION B - WCS = 20 deg - W/AVEGW - SLIDING BLOCK - STATIC
Surface #1-EASS.OUT. C:BEASSSP.PLT By: STAN KLINE 10-22-04 1:55am

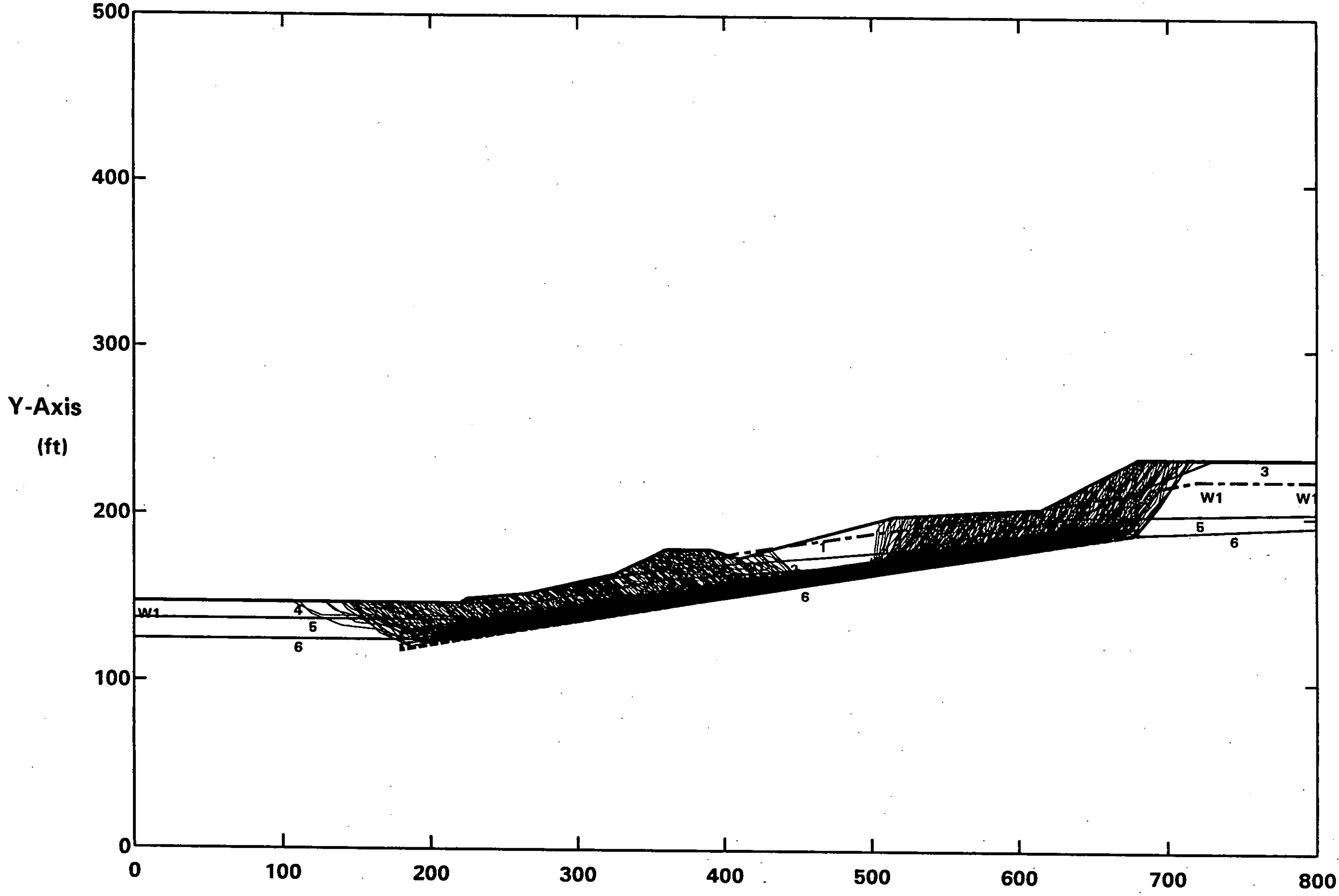


Label	Soil Type No.	Total Unit Wt. (pcf)	Saturated Unit Wt. (pcf)	Cohesion Intercept (psf)	Friction Angle (deg)	Pore Pressure Param.	Pressure Constant (psf)	Piez. Surface No.
WASTE	1	120	125	50	30	0	0	W1
Qc/SLIDE	2	120	125	0	20	0	0	W1
Qrf	3	120	125	0	37	0	0	W1
Qal	4	125	130	0	33	0	0	W1
WCS	5	120	125	0	20	0	0	W1
UCS	6	125	130	600	30	0	0	W1

PCSTABL5M/SI FS = 1.44 Theta = 9.49 X-Axis (ft)
Factors Of Safety Calculated By Spencer`s Method of Slices

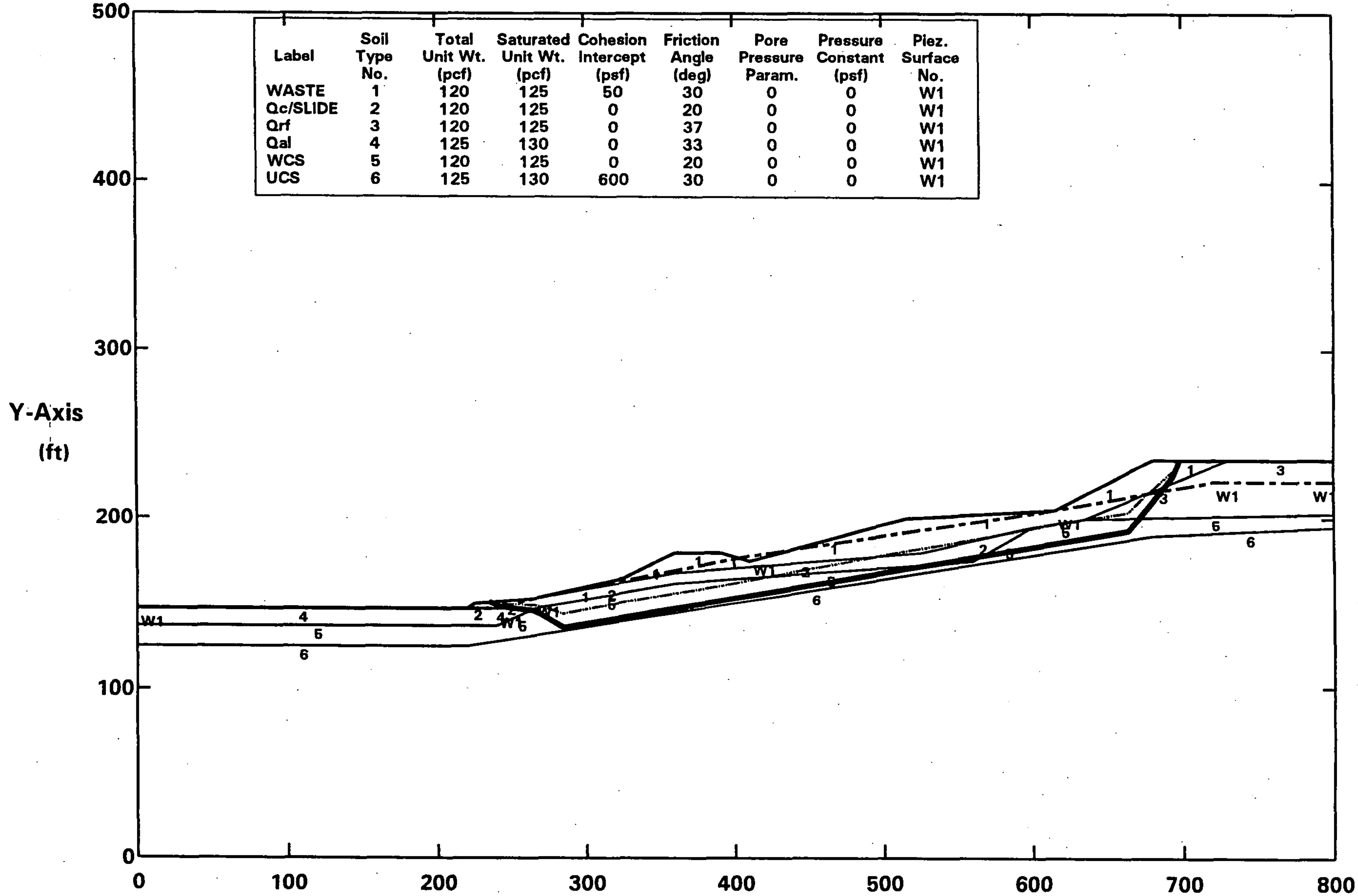
116

ROCKY FLATS OLF - M&E SECTION B - WCS=20 deg - W/HIGHGW - SLIDING BLOCK - STATIC
All surfaces evaluated. C:BEHSS.PLT By: STAN KLINE 10-23-04 7:03pm



Factors Of Safety Calculated By The Modified Janbu Method

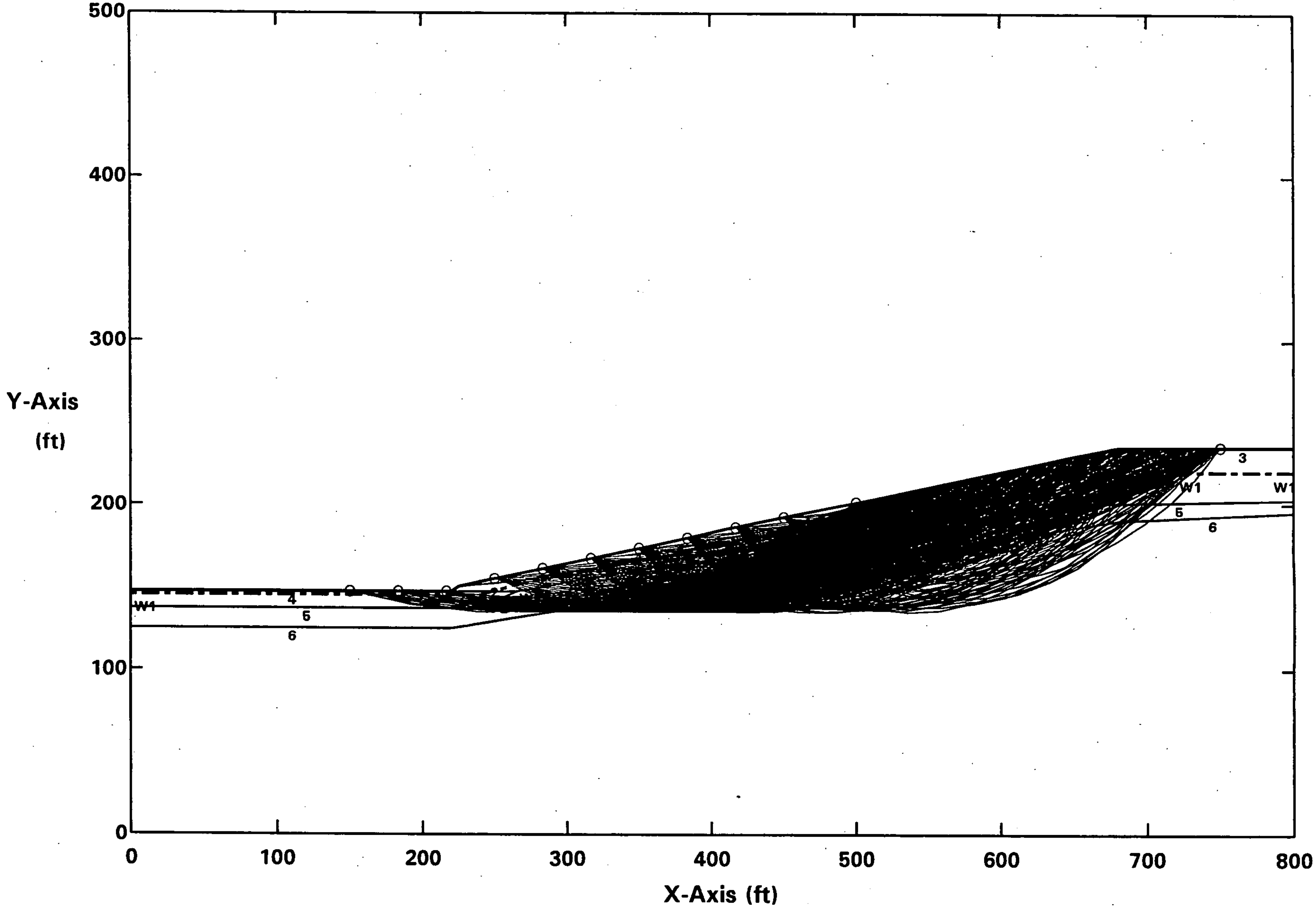
ROCKY FLATS OLF - M&E SECTION B - WCS = 20 deg - W/HIGHGW - SLIDING BLOCK - STATIC
Surface #1-EHSS.OUT. C:BEHSSSP.PLT By: STAN KLINE 10-22-04 1:27am



Label	Soil Type No.	Total Unit Wt. (pcf)	Saturated Unit Wt. (pcf)	Cohesion Intercept (psf)	Friction Angle (deg)	Pore Pressure Param.	Pressure Constant (psf)	Piez. Surface No.
WASTE	1	120	125	50	30	0	0	W1
Qc/SLIDE	2	120	125	0	20	0	0	W1
Qrf	3	120	125	0	37	0	0	W1
Qal	4	125	130	0	33	0	0	W1
WCS	5	120	125	0	20	0	0	W1
UCS	6	125	130	600	30	0	0	W1

PCSTABL5M/SI FS = 1.33 Theta = 9.16 X-Axis (ft)
Factors Of Safety Calculated By Spencer`s Method of Slices

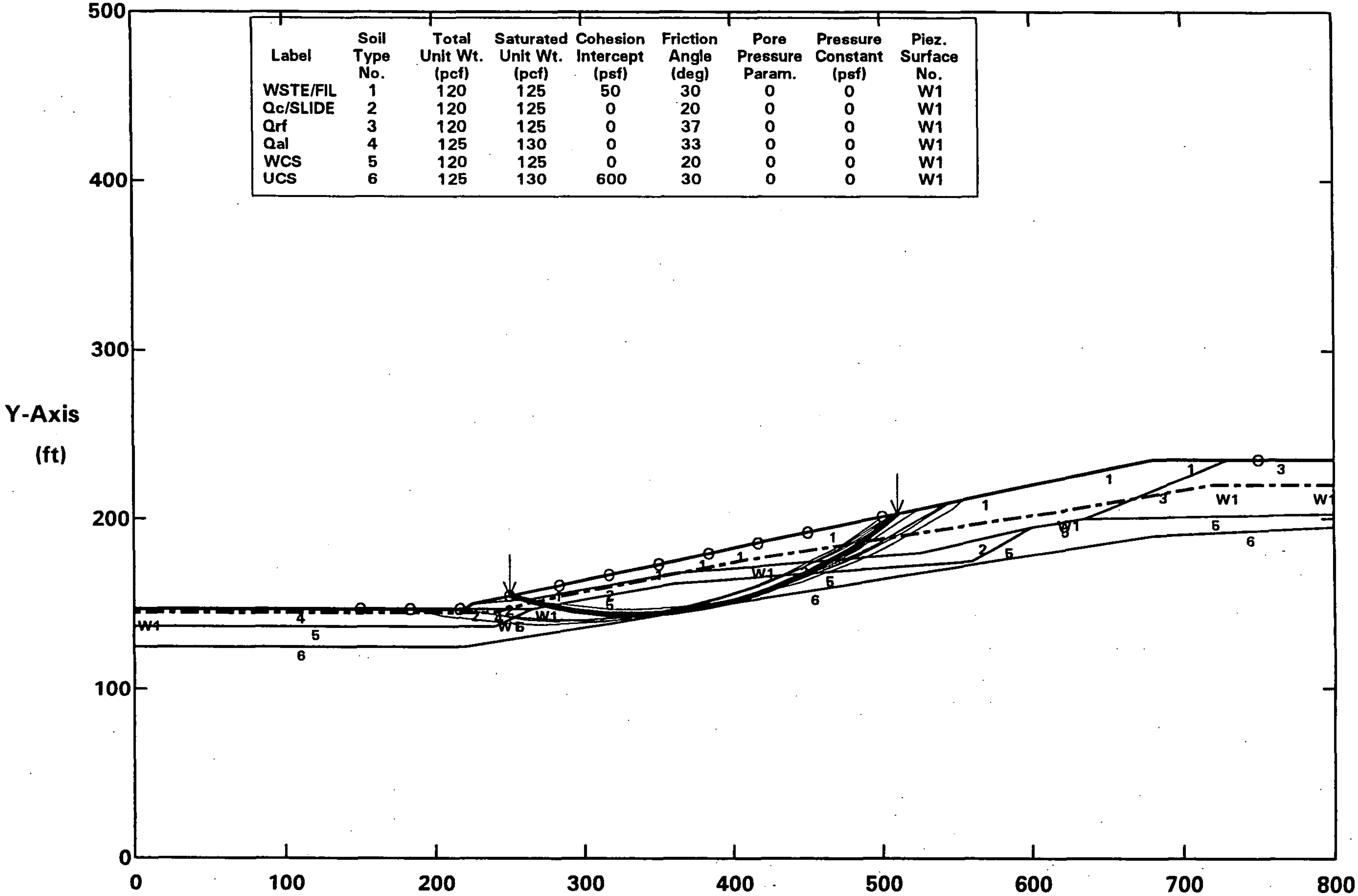
ROCKY FLATS OLF - M&E B 18% GRD - WCS = 20 deg - W/AVEGW - CIRCULAR - STATIC
All surfaces evaluated. C:BGACS.PLT By: STAN KLINE 10-22-04 2:19am



Factors Of Safety Calculated By The Modified Bishop Method

120

ROCKY FLATS OLF - M&E B 18% GRD - WCS = 20 deg - W/AVEGW - CIRCULAR - STATIC
Ten Most Critical. C:BGACS.PLT By: STAN KLINE 10-22-04 2:19am

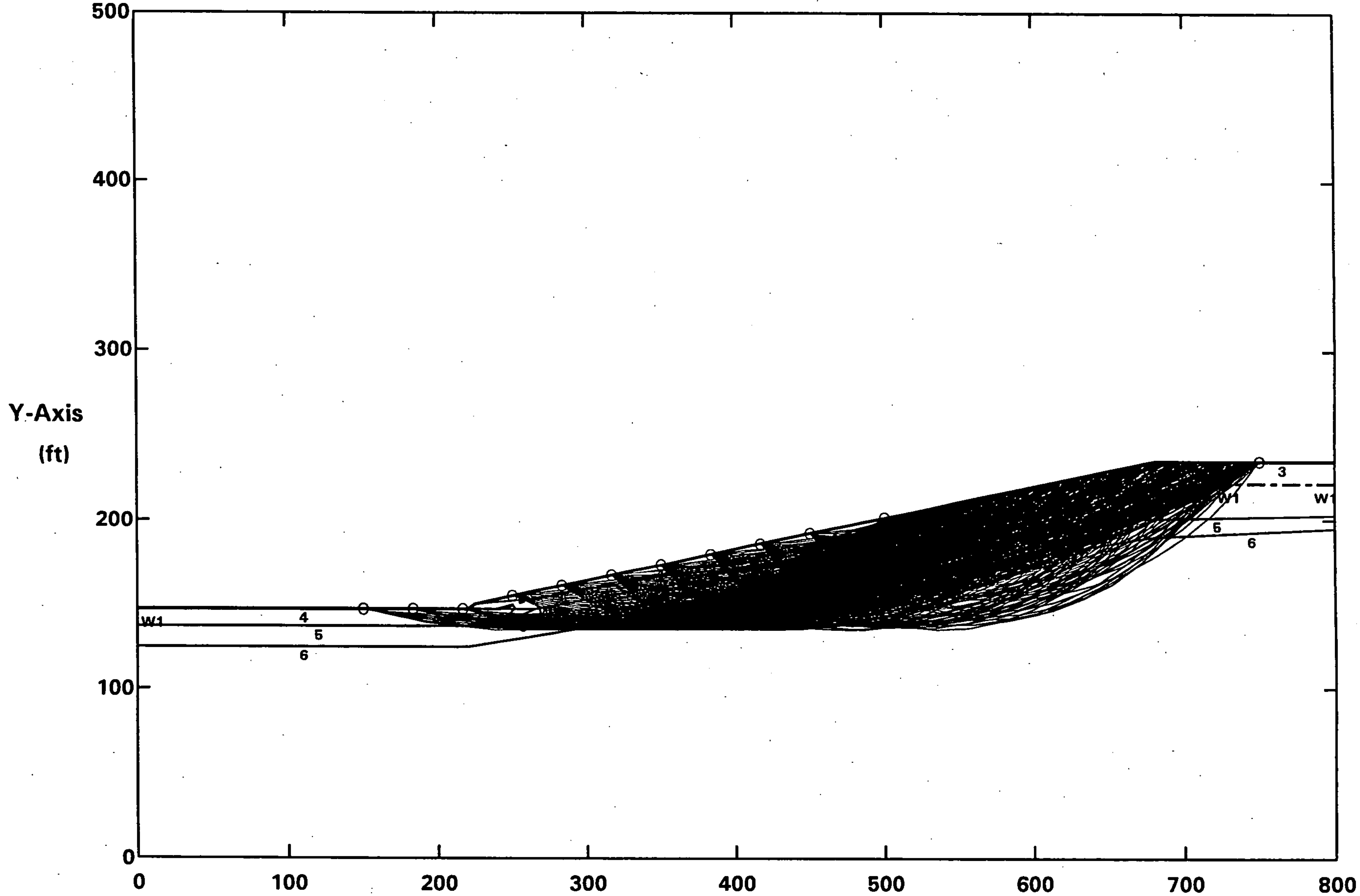


Label	Soil Type No.	Total Unit Wt. (pcf)	Saturated Unit Wt. (pcf)	Cohesion Intercept (psf)	Friction Angle (deg)	Pore Pressure Param.	Pressure Constant (psf)	Piez. Surface No.
WSTE/FIL	1	120	125	50	30	0	0	W1
Qc/SLIDE	2	120	125	0	20	0	0	W1
Qrf	3	120	125	0	37	0	0	W1
Qal	4	125	130	0	33	0	0	W1
WCS	5	120	125	0	20	0	0	W1
UCS	6	125	130	600	30	0	0	W1

PCSTABL5M/SI FSmin = 1.57 X-Axis (ft)
Factors Of Safety Calculated By The Modified Bishop Method

121

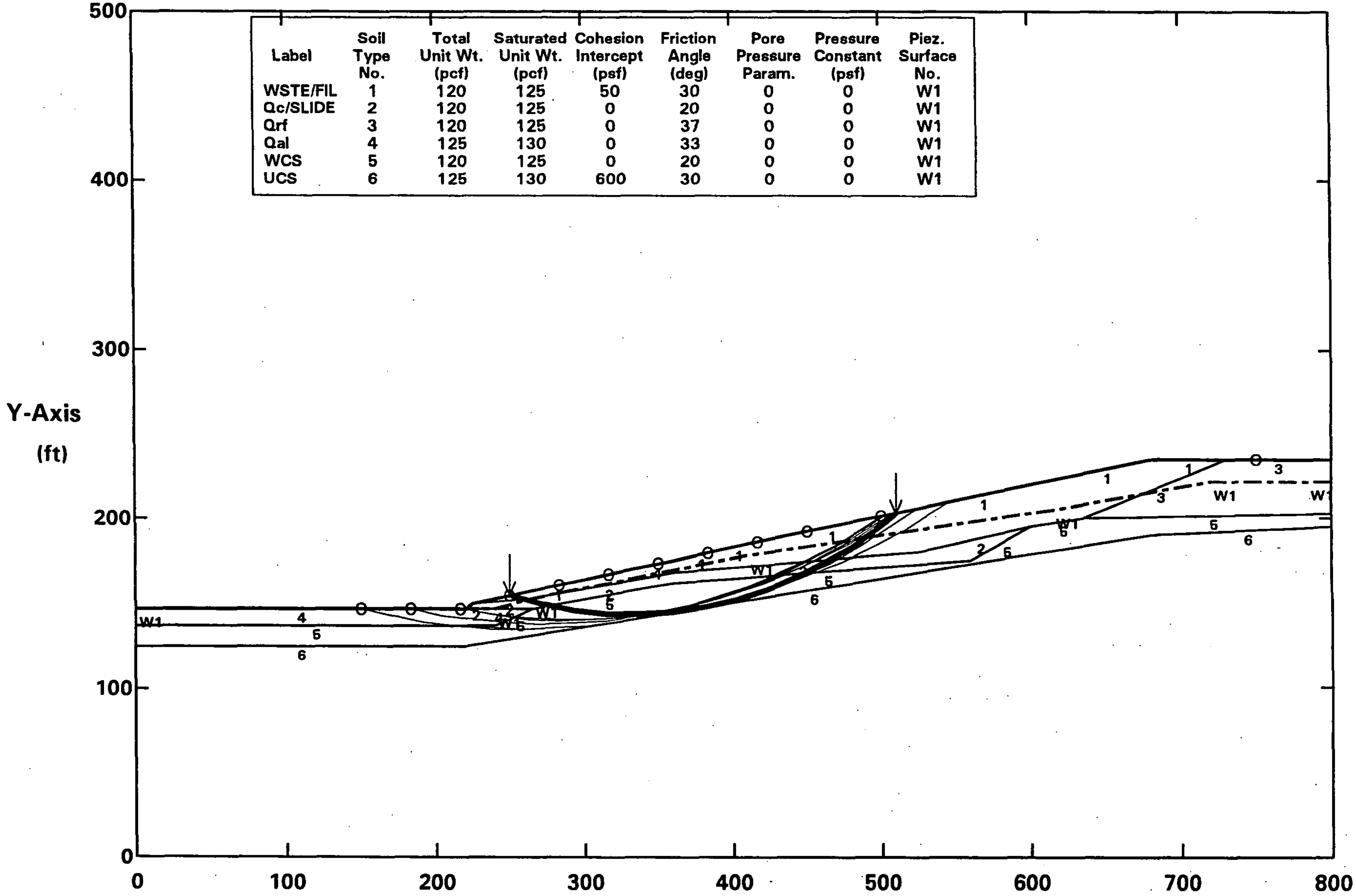
ROCKY FLATS OLF - M&E B 18% GRD - WCS = 20 deg - W/HIGHGW - CIRCULAR - STATIC
All surfaces evaluated. C:BGHCS.PLT By: STAN KLINE 10-25-04 12:10am



Factors Of Safety Calculated By The Modified Bishop Method

ROCKY FLATS OLF - M&E B 18% GRD - WCS = 20 deg - W/HIGHGW - CIRCULAR - STATIC

Ten Most Critical. C:BGHCS.PLT By: STAN KLINE 10-25-04 12:10am



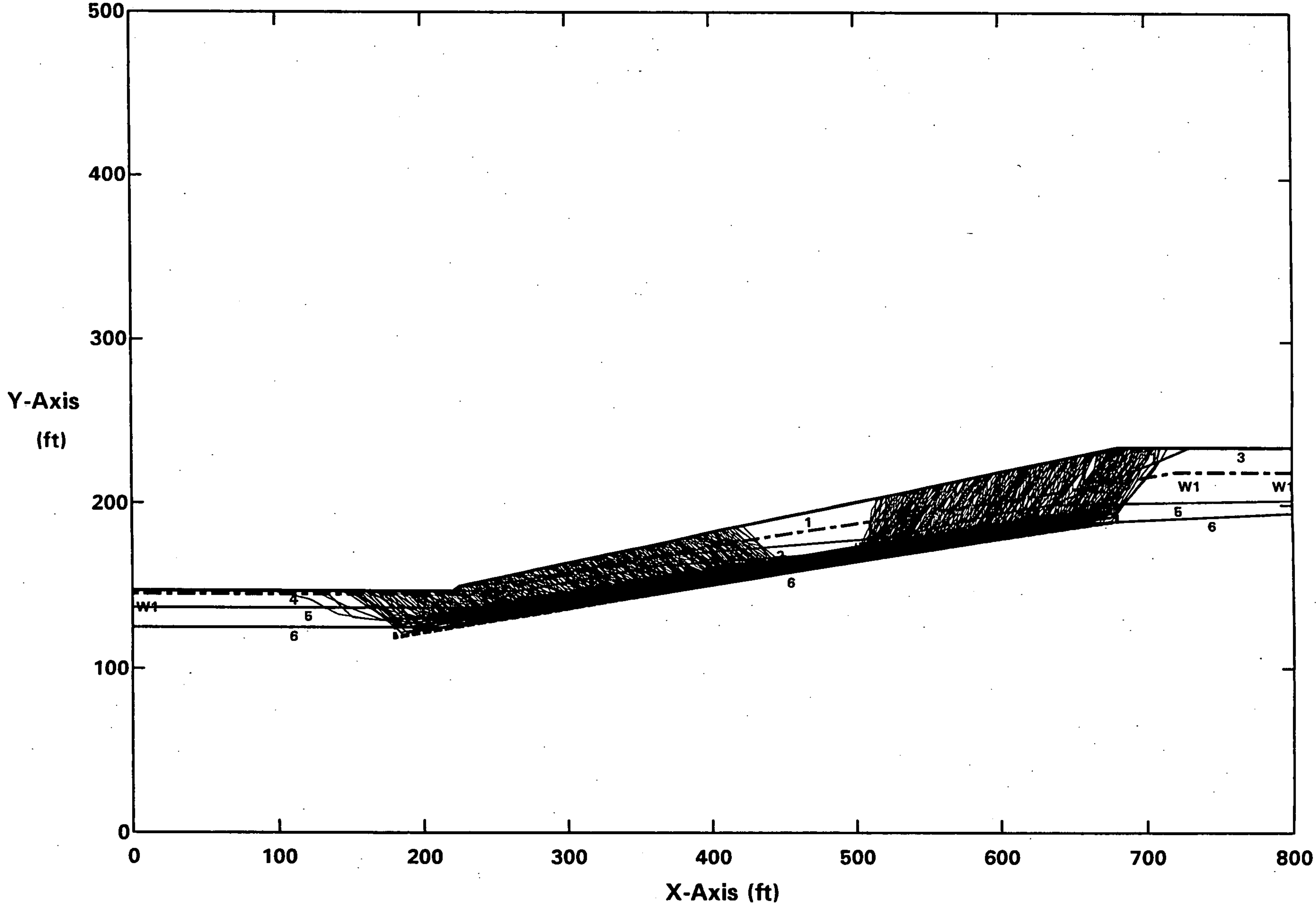
Label	Soil Type No.	Total Unit Wt. (pcf)	Saturated Unit Wt. (pcf)	Cohesion Intercept (psf)	Friction Angle (deg)	Pore Pressure Param.	Pressure Constant (psf)	Piez. Surface No.
WSTE/FIL	1	120	125	50	30	0	0	W1
Qc/SLIDE	2	120	125	0	20	0	0	W1
Qrf	3	120	125	0	37	0	0	W1
Qal	4	125	130	0	33	0	0	W1
WCS	5	120	125	0	20	0	0	W1
UCS	6	125	130	600	30	0	0	W1

PCSTABL5M/SI FSmin = 1.48 X-Axis (ft)

Factors Of Safety Calculated By The Modified Bishop Method

123

ROCKY FLATS OLF - M&E B 18% GRD - WCS=20 deg - W/AVEGW - SLIDING BLOCK - STATIC
All surfaces evaluated. C:BGASS.PLT By: STAN KLINE 10-22-04 12:13am

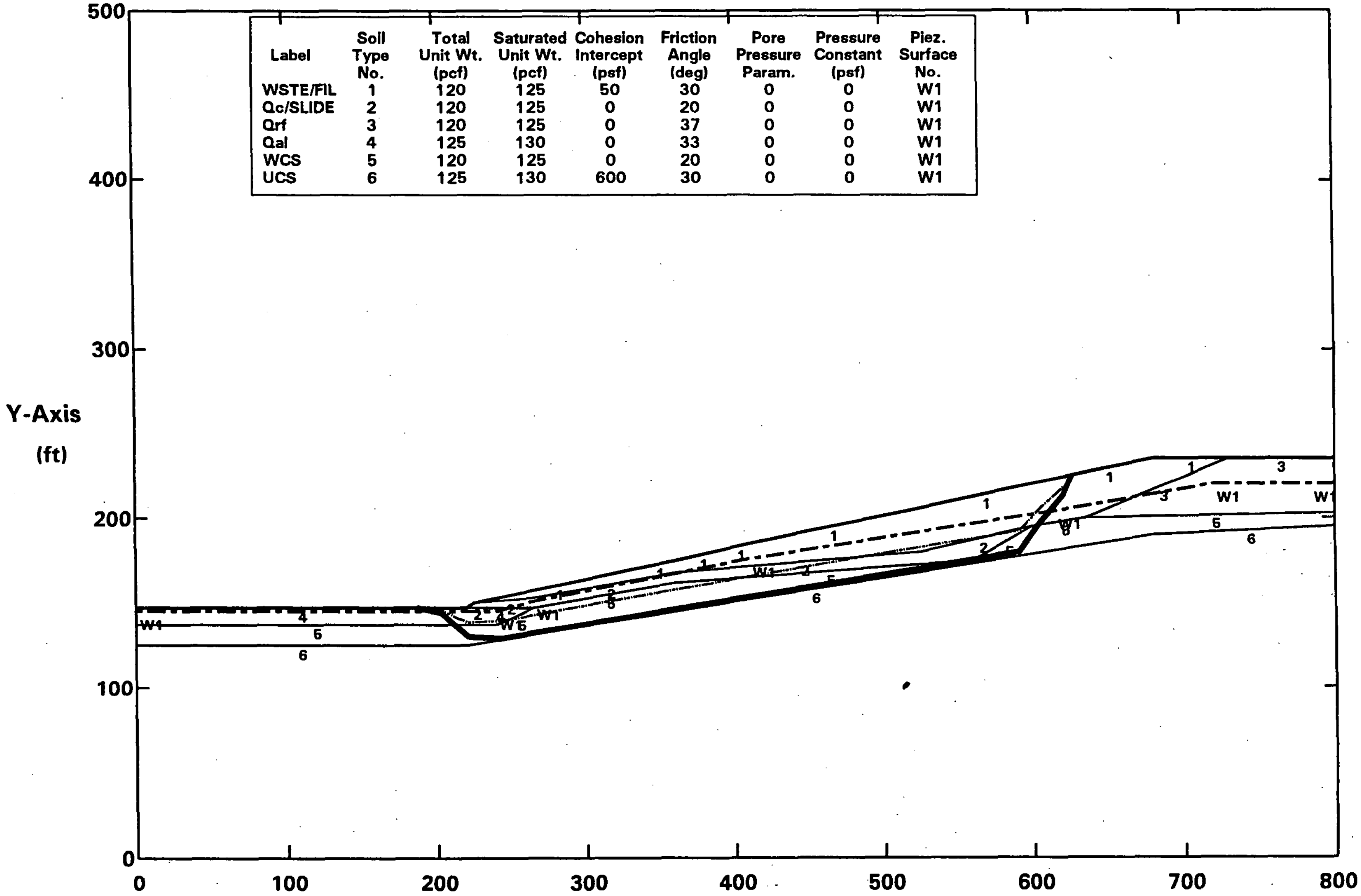


Factors Of Safety Calculated By The Modified Janbu Method

124

ROCKY FLATS OLF - M&E B 18% GRD - WCS = 20 deg - W/AVEGW - SLIDING BLOCK - STATIC
Surface #1-GASS.OUT. C:BGASSSP.PLT By: STAN KLINE 10-22-04 12:20am

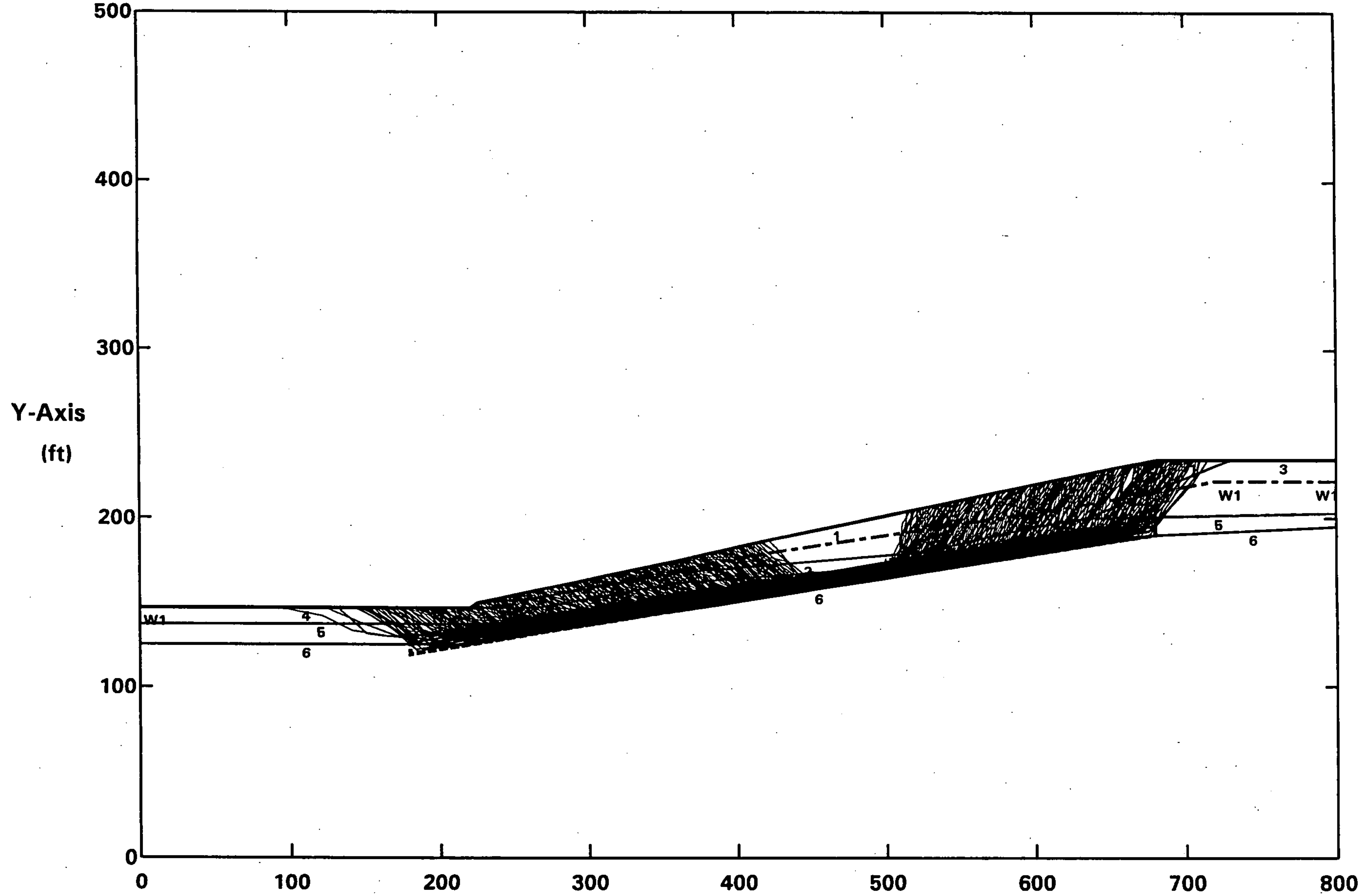
Label	Soil Type No.	Total Unit Wt. (pcf)	Saturated Unit Wt. (pcf)	Cohesion Intercept (psf)	Friction Angle (deg)	Pore Pressure Param.	Pressure Constant (psf)	Piez. Surface No.
WSTE/FIL	1	120	125	50	30	0	0	W1
Qc/SLIDE	2	120	125	0	20	0	0	W1
Qrf	3	120	125	0	37	0	0	W1
Qal	4	125	130	0	33	0	0	W1
WCS	5	120	125	0	20	0	0	W1
UCS	6	125	130	600	30	0	0	W1



PCSTABL5M/SI FS = 1.57 Theta = 8.94 X-Axis (ft)
Factors Of Safety Calculated By Spencer`s Method of Slices

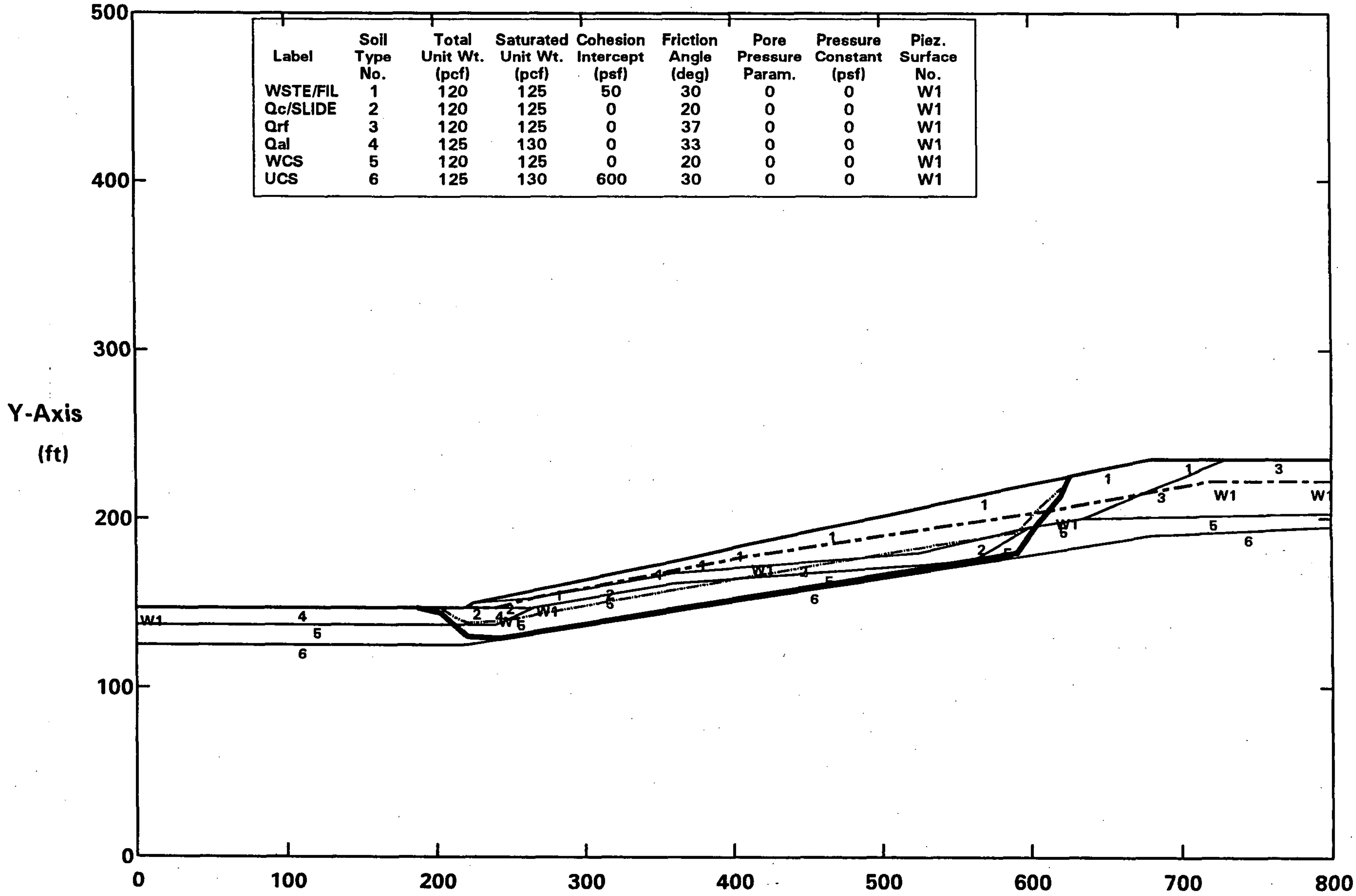
125

ROCKY FLATS OLF - M&E B 18% GRD - WCS=20 deg - W/HIGHGW - SLIDING BLOCK - STATIC
All surfaces evaluated. C:BGHSS.PLT By: STAN KLINE 10-25-04 12:14am



Factors Of Safety Calculated By The Modified Janbu Method

ROCKY FLATS OLF - M&E B 18% GRD - WCS=20 deg - W/HIGHGW - SLIDING BLOCK - STATIC
Surface #1-BGHSS.OUT. C:BGHSSSP.PLT By: STAN KLINE 10-25-04 12:15am



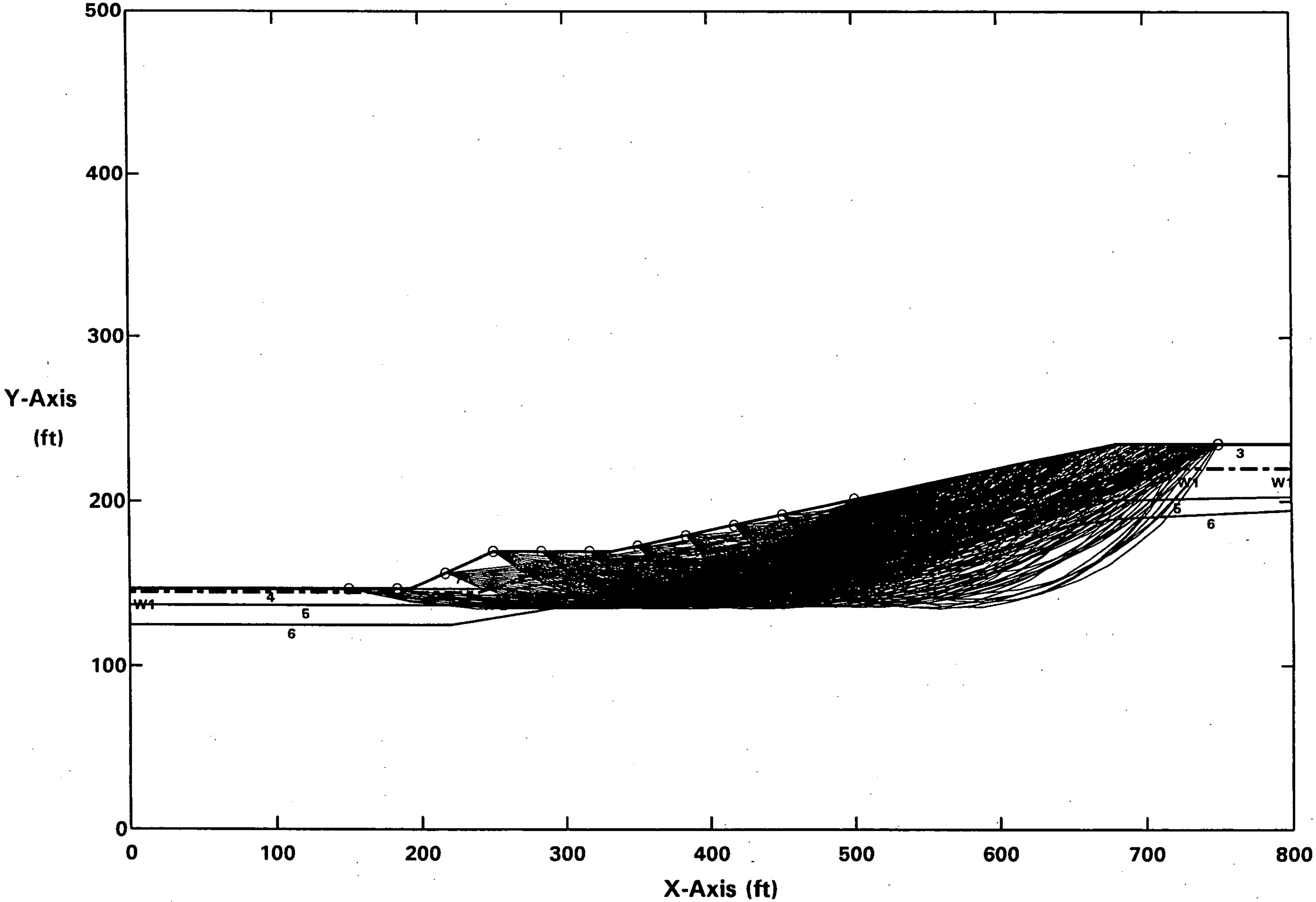
PCSTABL5M/SI FS=1.50 Theta=8.98 X-Axis (ft)
Factors Of Safety Calculated By Spencer`s Method of Slices

18% REGRADE WITH BUTTRESS CONDITION

129

128

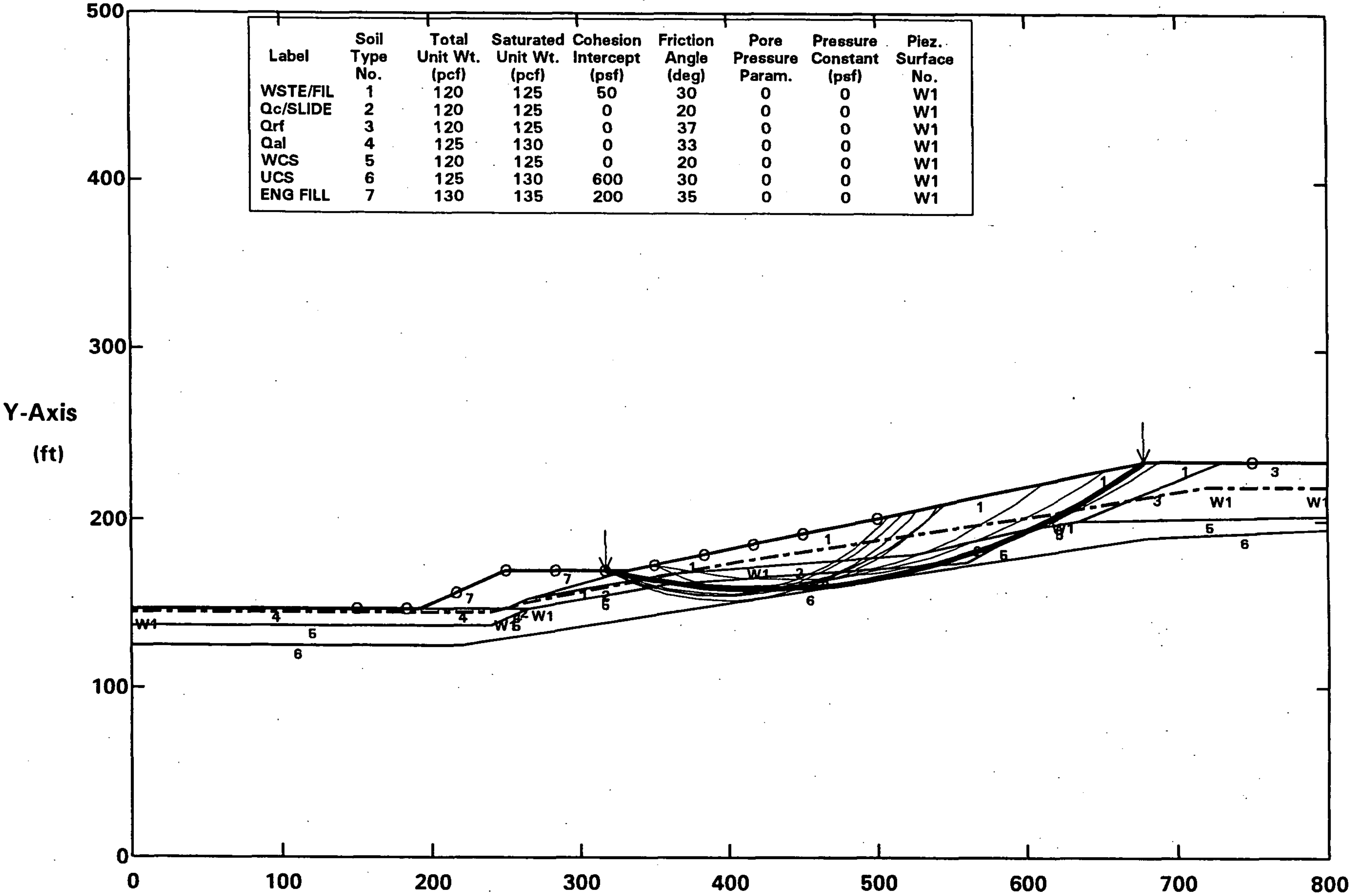
ROCKY FLATS OLF - M&E B 18%W/BM - WCS=20 deg - W/AVEGW - CIRCULAR - STATIC
All surfaces evaluated. C:BBACS.PLT By: STAN KLINE 10-22-04 2:26am



Factors Of Safety Calculated By The Modified Bishop Method

129

ROCKY FLATS OLF - M&E B 18%W/BM - WCS = 20 deg - W/AVEGW - CIRCULAR - STATIC
Ten Most Critical. C:BBACS.PLT By: STAN KLINE 10-22-04 2:26am

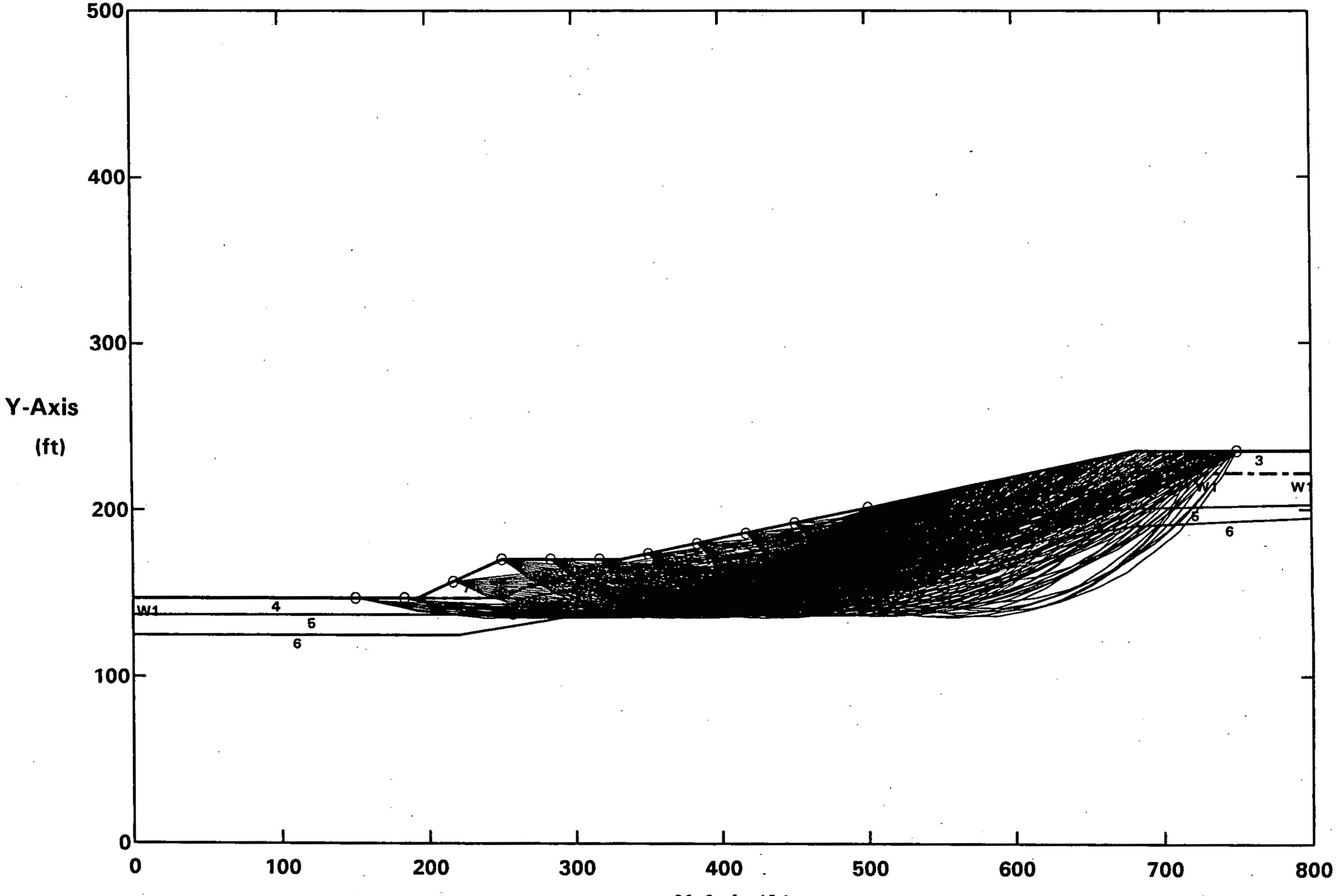


Label	Soil Type No.	Total Unit Wt. (pcf)	Saturated Unit Wt. (pcf)	Cohesion Intercept (psf)	Friction Angle (deg)	Pore Pressure Param.	Pressure Constant (psf)	Piez. Surface No.
WSTE/FIL	1	120	125	50	30	0	0	W1
Qc/SLIDE	2	120	125	0	20	0	0	W1
Qrf	3	120	125	0	37	0	0	W1
Qal	4	125	130	0	33	0	0	W1
WCS	5	120	125	0	20	0	0	W1
UCS	6	125	130	600	30	0	0	W1
ENG FILL	7	130	135	200	35	0	0	W1

PCSTABL5M/SI FSmin = 1.72 X-Axis (ft)
Factors Of Safety Calculated By The Modified Bishop Method

130

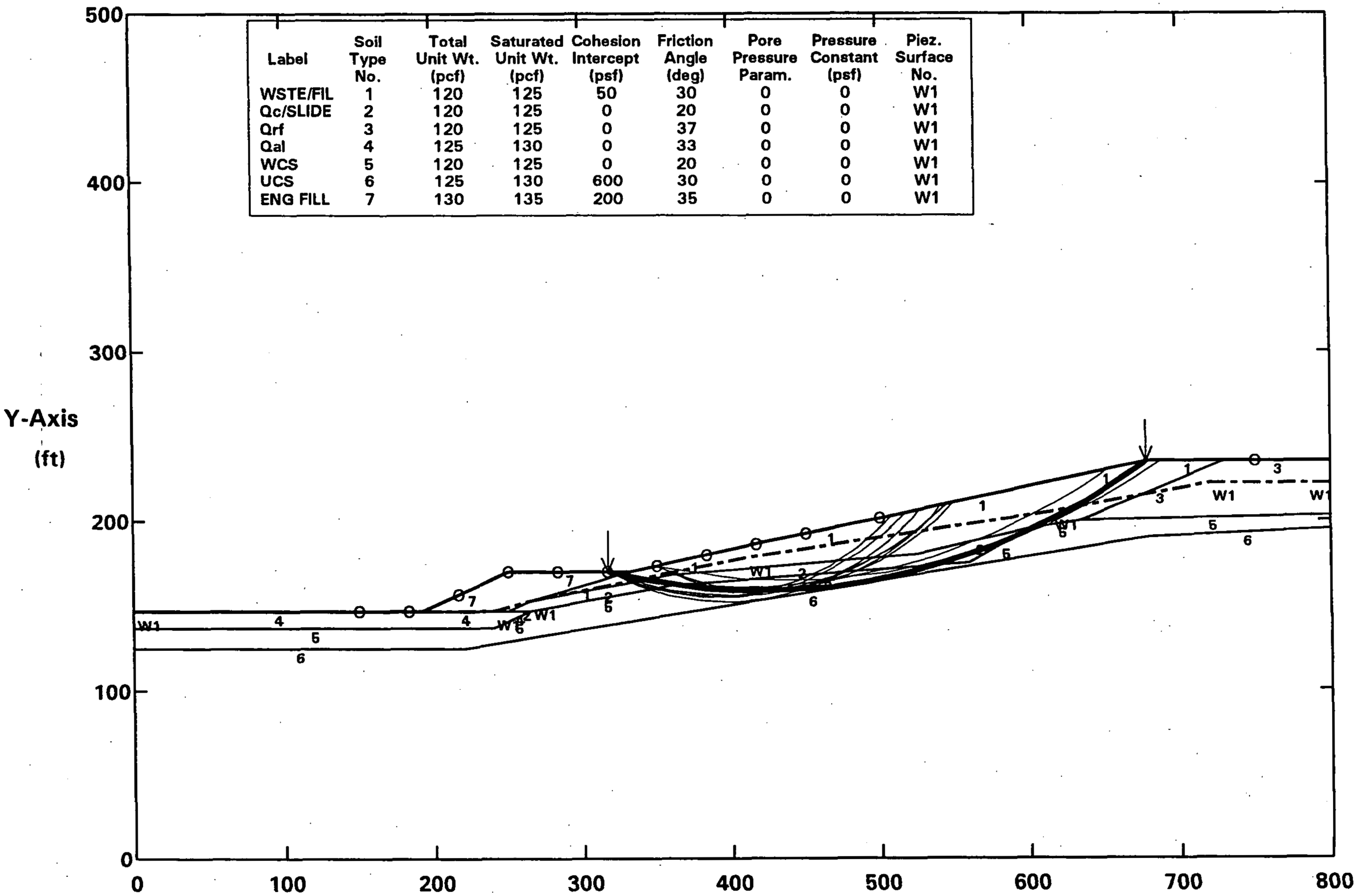
ROCKY FLATS OLF - M&E B 18%W/BM - WCS=20 deg - W/HIGHGW - CIRCULAR - STATIC
All surfaces evaluated. C:BBHCS.PLT By: STAN KLINE 10-22-04 2:42am



Factors Of Safety Calculated By The Modified Bishop Method

131

ROCKY FLATS OLF - M&E B 18%W/BM - WCS=20 deg - W/HIGHGW - CIRCULAR - STATIC
Ten Most Critical. C:BBHCS.PLT By: STAN KLINE 10-22-04 2:42am

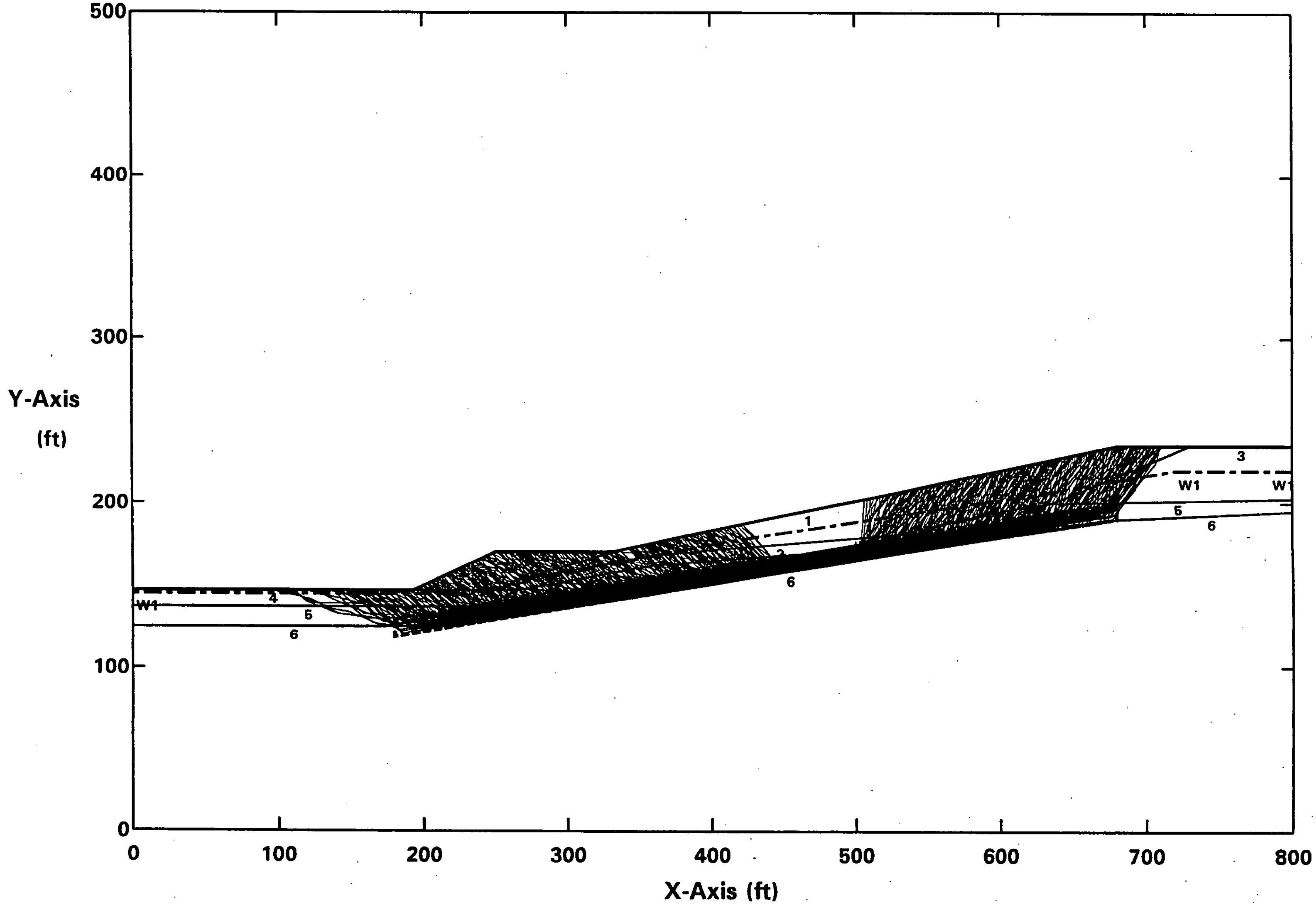


Label	Soil Type No.	Total Unit Wt. (pcf)	Saturated Unit Wt. (pcf)	Cohesion Intercept (psf)	Friction Angle (deg)	Pore Pressure Param.	Pressure Constant (psf)	Piez. Surface No.
WSTE/FIL	1	120	125	50	30	0	0	W1
Qc/SLIDE	2	120	125	0	20	0	0	W1
Qrf	3	120	125	0	37	0	0	W1
Qal	4	125	130	0	33	0	0	W1
WCS	5	120	125	0	20	0	0	W1
UCS	6	125	130	600	30	0	0	W1
ENG FILL	7	130	135	200	35	0	0	W1

PCSTABL5M/SI FSmin=1.66 X-Axis (ft)
Factors Of Safety Calculated By The Modified Bishop Method

132

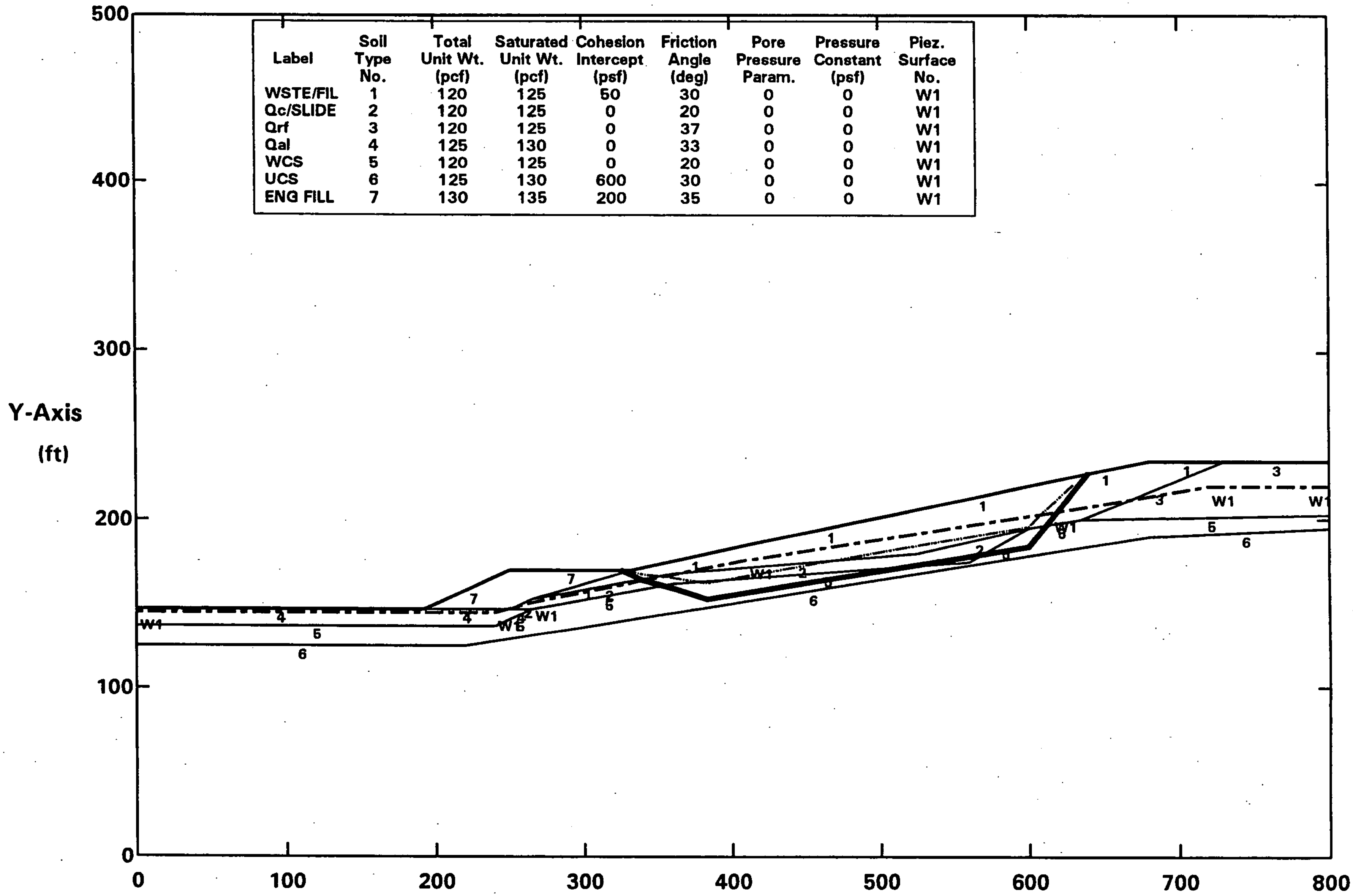
ROCKY FLATS OLF - M&E B 18%W/BM - WCS=20 deg - W/AVEGW - SLIDING BLOCK - STATIC
All surfaces evaluated. C:BBASS.PLT By: STAN KLINE 10-22-04 2:03am



Factors Of Safety Calculated By The Modified Janbu Method

133

ROCKY FLATS OLF - M&E B 18%W/BM - WCS=20 deg - W/AVEGW - SLIDING BLOCK - STATIC
Surface #1-BASS.OUT. C:BBASSSP.PLT By: STAN KLINE 10-22-04 2:05am

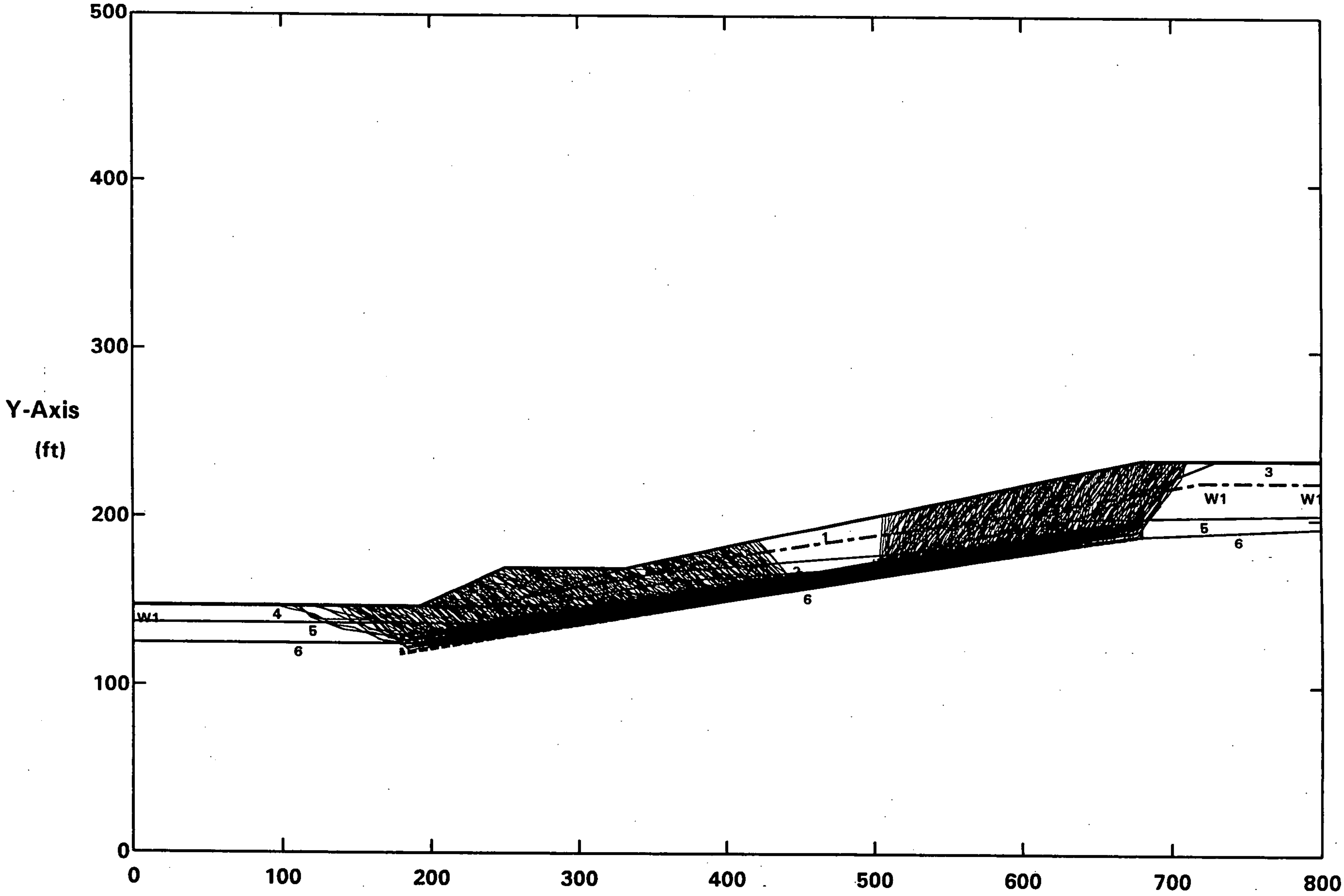


Label	Soil Type No.	Total Unit Wt. (pcf)	Saturated Unit Wt. (pcf)	Cohesion Intercept (psf)	Friction Angle (deg)	Pore Pressure Param.	Pressure Constant (psf)	Piez. Surface No.
WSTE/FIL	1	120	125	50	30	0	0	W1
Qc/SLIDE	2	120	125	0	20	0	0	W1
Qrf	3	120	125	0	37	0	0	W1
Qal	4	125	130	0	33	0	0	W1
WCS	5	120	125	0	20	0	0	W1
UCS	6	125	130	600	30	0	0	W1
ENG FILL	7	130	135	200	35	0	0	W1

PCSTABL5M/SI FS=1.71 Theta=8.92 X-Axis (ft)
Factors Of Safety Calculated By Spencer`s Method of Slices

134

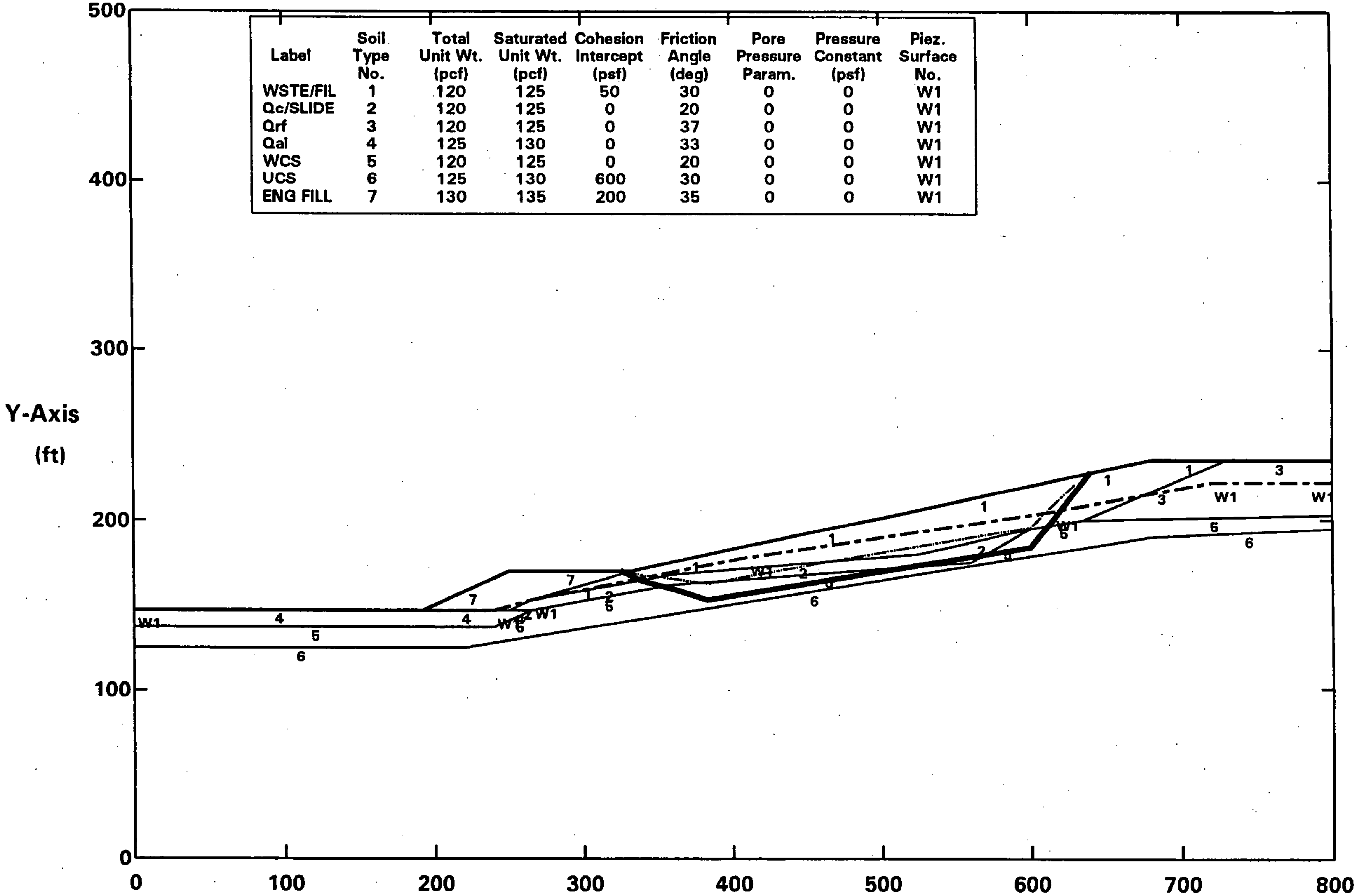
ROCKY FLATS OLF - M&E B 18%W/BM - WCS=20 deg - W/HIGHGW - SLIDING BLOCK - STATIC
All surfaces evaluated. C:BBHSS.PLT By: STAN KLINE 10-22-04 1:35am



Factors Of Safety Calculated By The Modified Janbu Method

135

ROCKY FLATS OLF - M&E B 18%W/BM - WCS=20 deg - W/HIGHGW - SLIDING BLOCK - STATIC
Surface #1-BHSS.OUT. C:BBHSSSP.PLT By: STAN KLINE 10-22-04 1:37am



Label	Soil Type No.	Total Unit Wt. (pcf)	Saturated Unit Wt. (pcf)	Cohesion Intercept (psf)	Friction Angle (deg)	Pore Pressure Param.	Pressure Constant (psf)	Piez. Surface No.
WSTE/FIL	1	120	125	50	30	0	0	W1
Qc/SLIDE	2	120	125	0	20	0	0	W1
Qrf	3	120	125	0	37	0	0	W1
Qal	4	125	130	0	33	0	0	W1
WCS	5	120	125	0	20	0	0	W1
UCS	6	125	130	600	30	0	0	W1
ENG FILL	7	130	135	200	35	0	0	W1

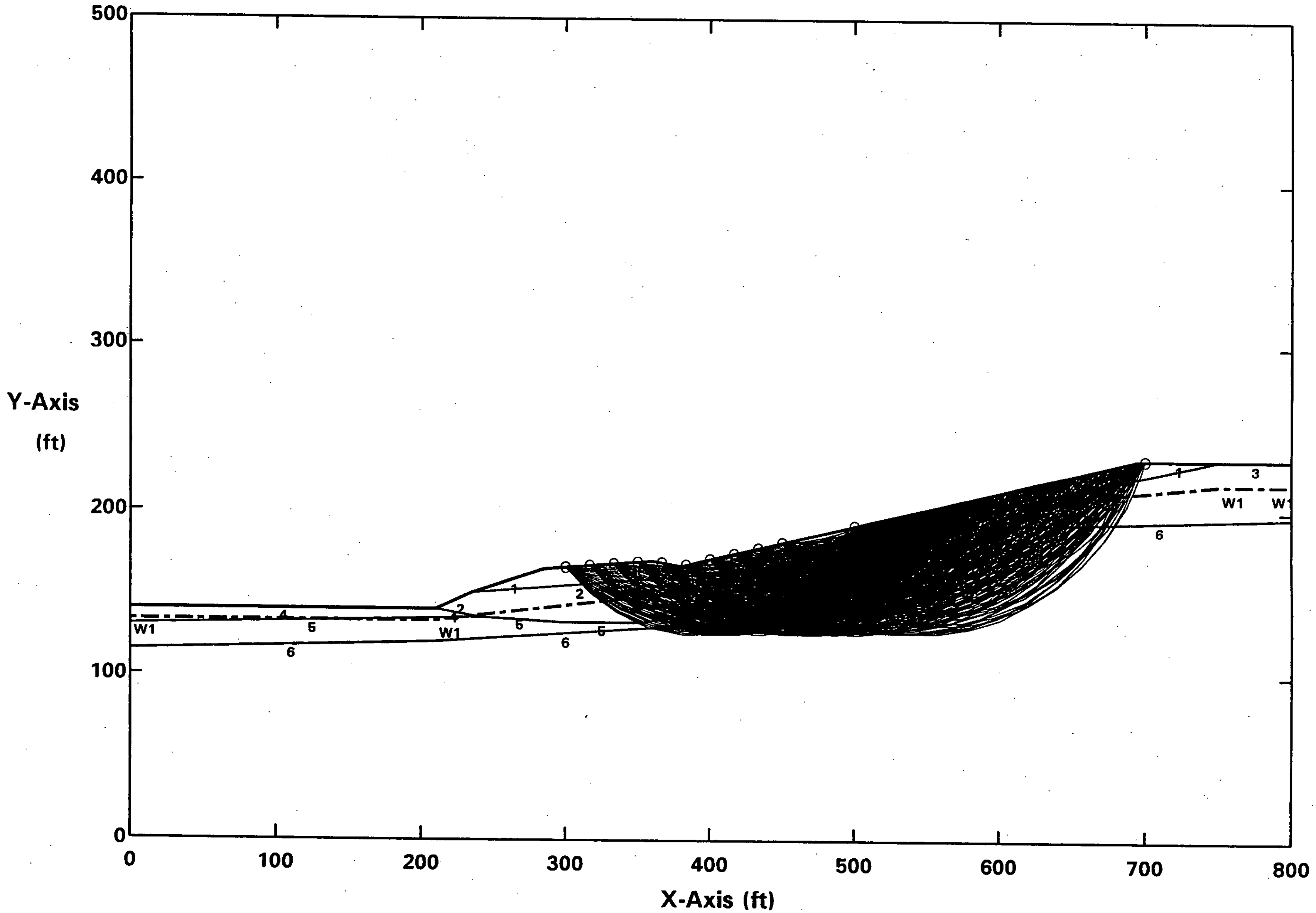
PCSTABL5M/SI FS=1.65 Theta=8.87 X-Axis (ft)
Factors Of Safety Calculated By Spencer`s Method of Slices

M&E SECTION C-C' – STATIC

136

EXISTING CONDITIONS

ROCKY FLATS OLF - M&E SECTION C - WCS=20 deg - W/AVEGW - CIRCULAR - STATIC
All surfaces evaluated. C:CEACS.PLT By: STAN KLINE 10-23-04 10:18pm

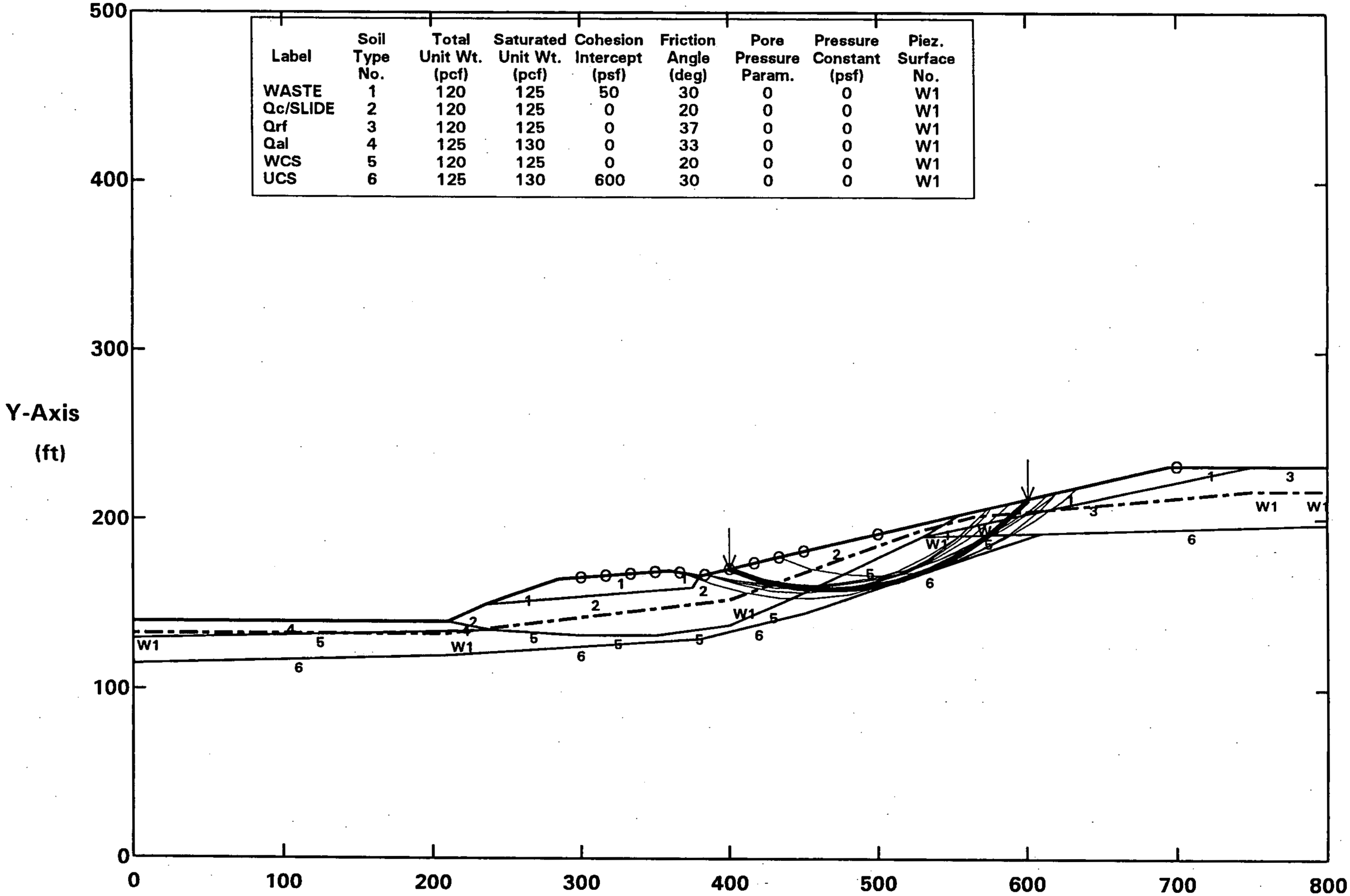


Factors Of Safety Calculated By The Modified Bishop Method

139

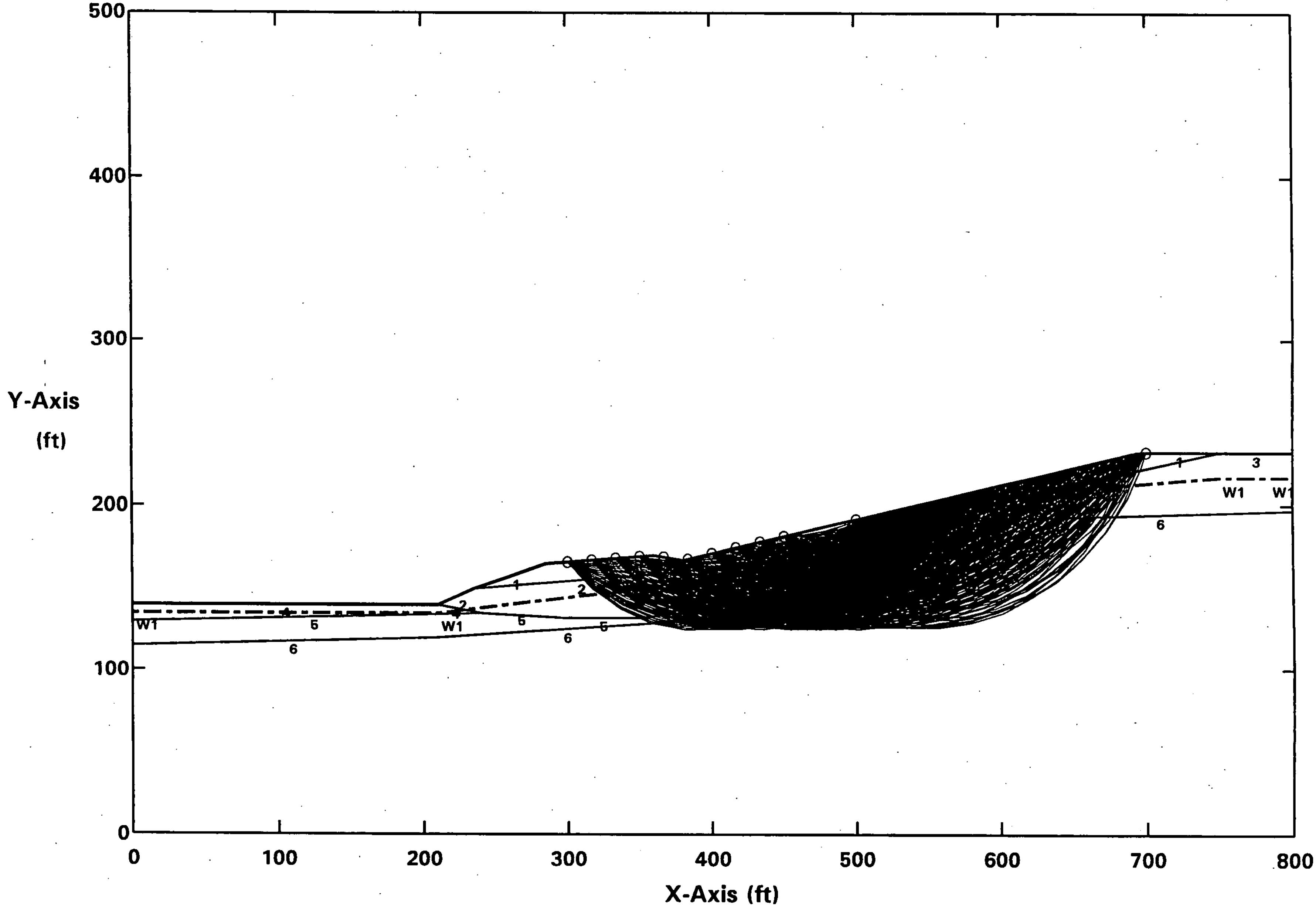
ROCKY FLATS OLF - M&E SECTION C - WCS = 20 deg - W/AVEGW - CIRCULAR - STATIC
Ten Most Critical. C:CEACS.PLT By: STAN KLINE 10-23-04 10:18pm

Label	Soil Type No.	Total Unit Wt. (pcf)	Saturated Unit Wt. (pcf)	Cohesion Intercept (psf)	Friction Angle (deg)	Pore Pressure Param.	Pressure Constant (psf)	Piez. Surface No.
WASTE	1	120	125	50	30	0	0	W1
Qc/SLIDE	2	120	125	0	20	0	0	W1
Qrf	3	120	125	0	37	0	0	W1
Qal	4	125	130	0	33	0	0	W1
WCS	5	120	125	0	20	0	0	W1
UCS	6	125	130	600	30	0	0	W1



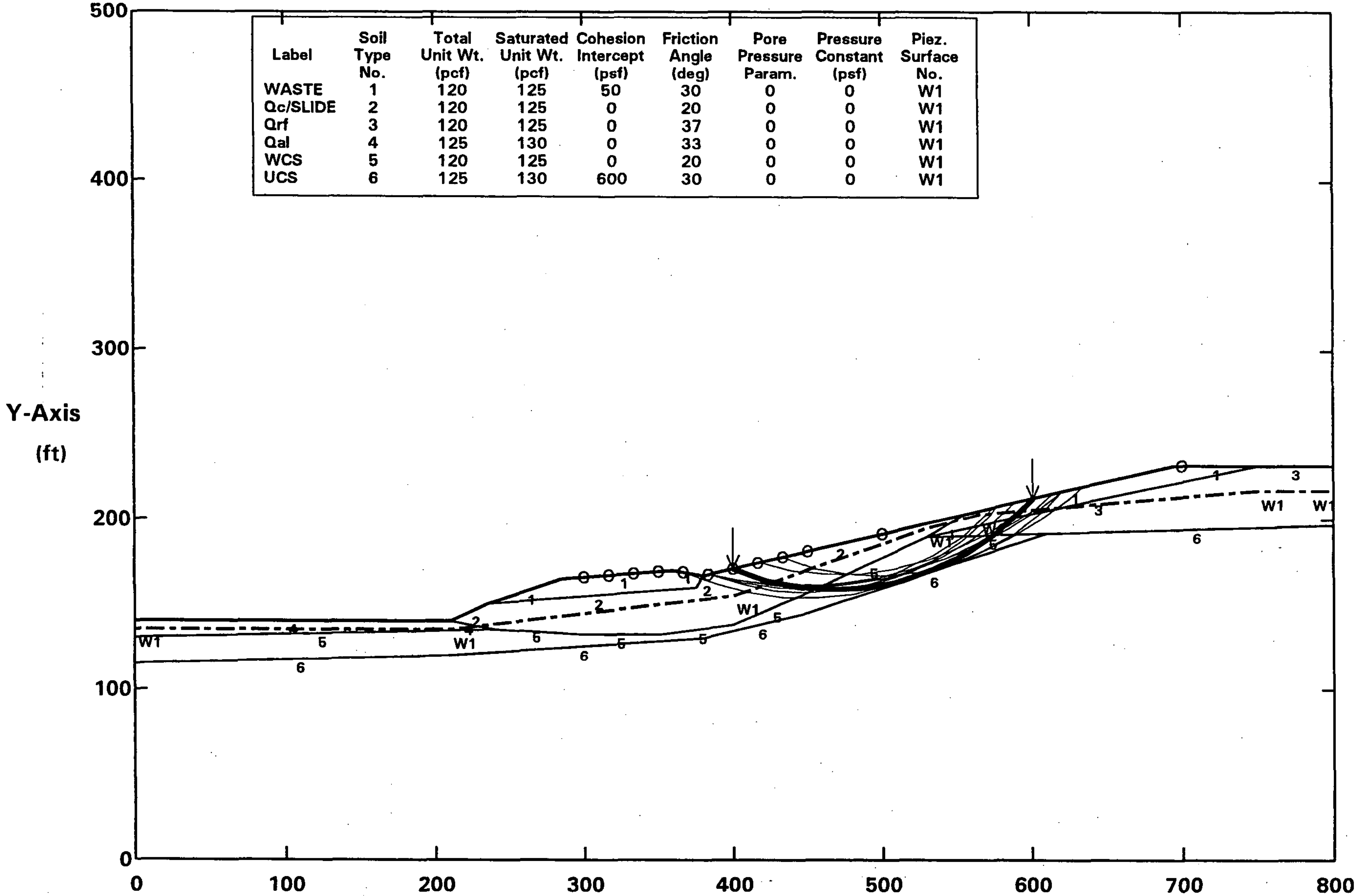
PCSTABL5M/SI FSmin = 1.42 X-Axis (ft)
Factors Of Safety Calculated By The Modified Bishop Method

ROCKY FLATS OLF - M&E SECTION C - WCS = 20 deg - W/HIGHGW - CIRCULAR - STATIC
All surfaces evaluated. C:CEHCS.PLT By: STAN KLINE 10-23-04 9:37pm



Factors Of Safety Calculated By The Modified Bishop Method

ROCKY FLATS OLF - M&E SECTION C - WCS = 20 deg - W/HIGHGW - CIRCULAR - STATIC
Ten Most Critical. C:CEHCS.PLT By: STAN KLINE 10-23-04 9:37pm

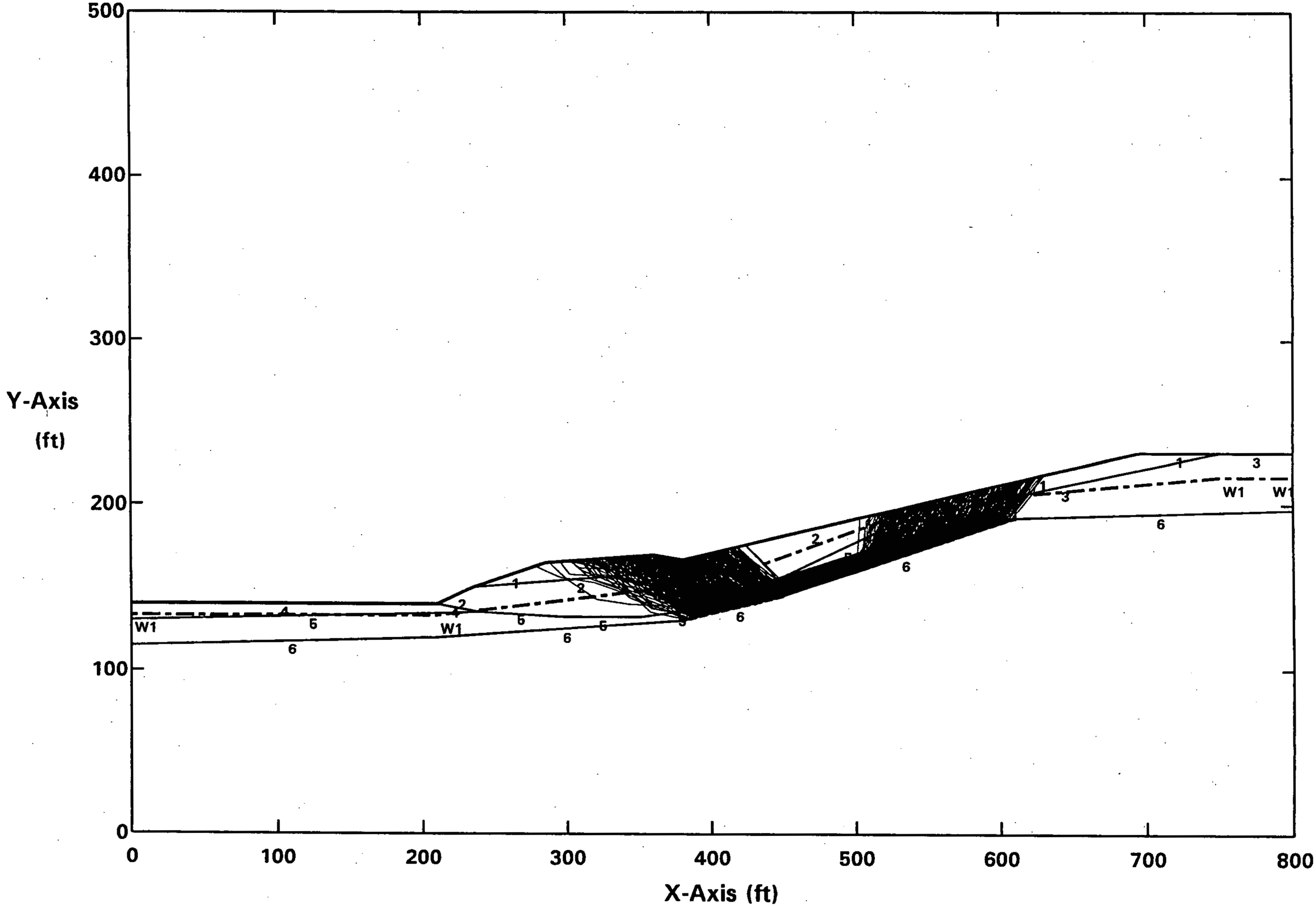


Label	Soil Type No.	Total Unit Wt. (pcf)	Saturated Unit Wt. (pcf)	Cohesion Intercept (psf)	Friction Angle (deg)	Pore Pressure Param.	Pressure Constant (psf)	Piez. Surface No.
WASTE	1	120	125	50	30	0	0	W1
Qc/SLIDE	2	120	125	0	20	0	0	W1
Qrf	3	120	125	0	37	0	0	W1
Qal	4	125	130	0	33	0	0	W1
WCS	5	120	125	0	20	0	0	W1
UCS	6	125	130	600	30	0	0	W1

PCSTABL5M/SI FSmin = 1.37 X-Axis (ft)
Factors Of Safety Calculated By The Modified Bishop Method

142

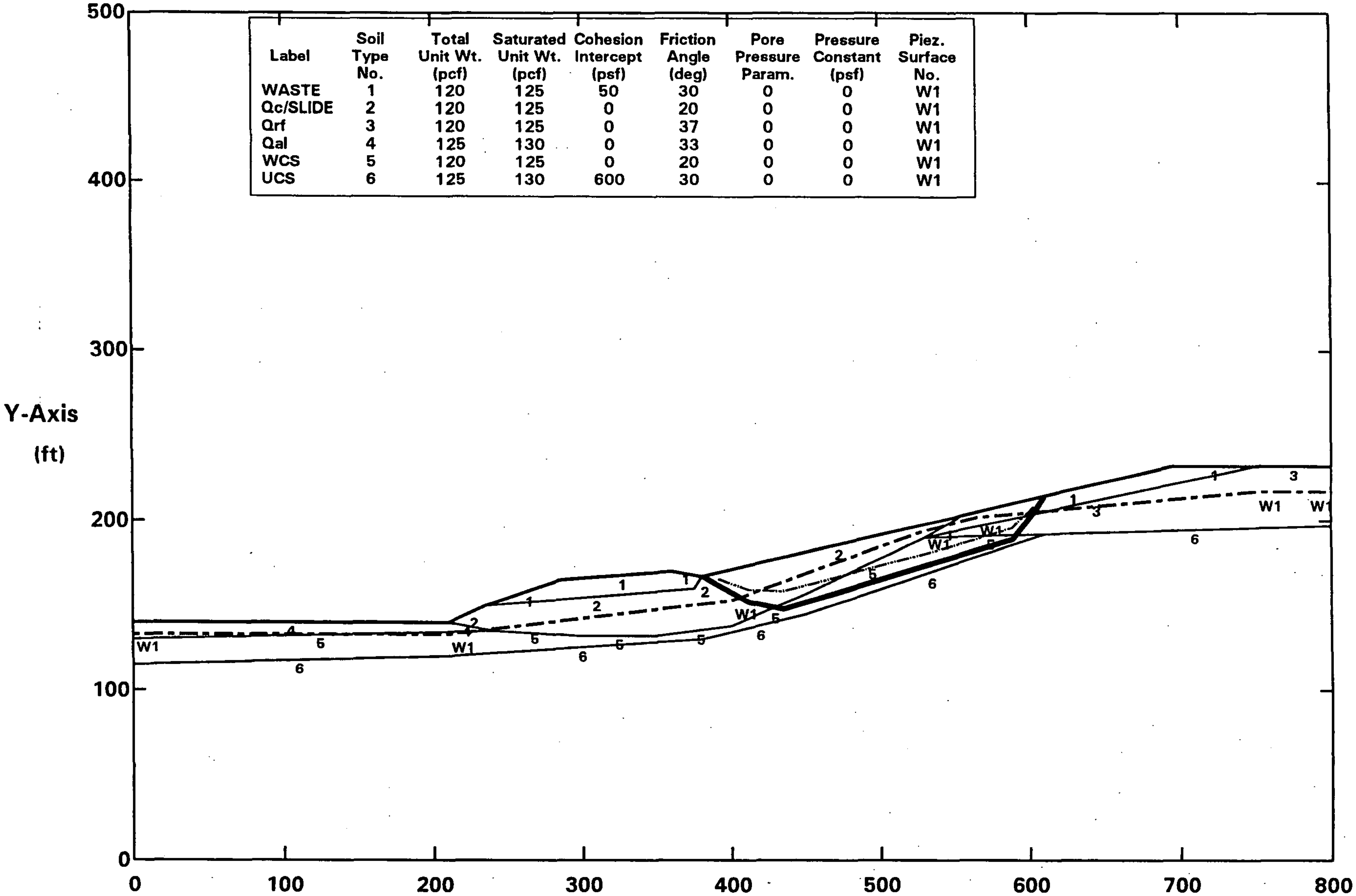
ROCKY FLATS OLF - M&E SECTION C - WCS = 20 deg - W/AVEGW - SLIDING BLOCK - STATIC
All surfaces evaluated. C:CEASS.PLT By: STAN KLINE 10-23-04 10:24pm



Factors Of Safety Calculated By The Modified Janbu Method

142

ROCKY FLATS OLF - M&E SECTION C - WCS = 20 deg - W/AVEGW - SLIDING BLOCK - STATIC
Surface #1-CEASS.OUT. C:CEASSSP.PLT By: STAN KLINE 10-23-04 10:25pm

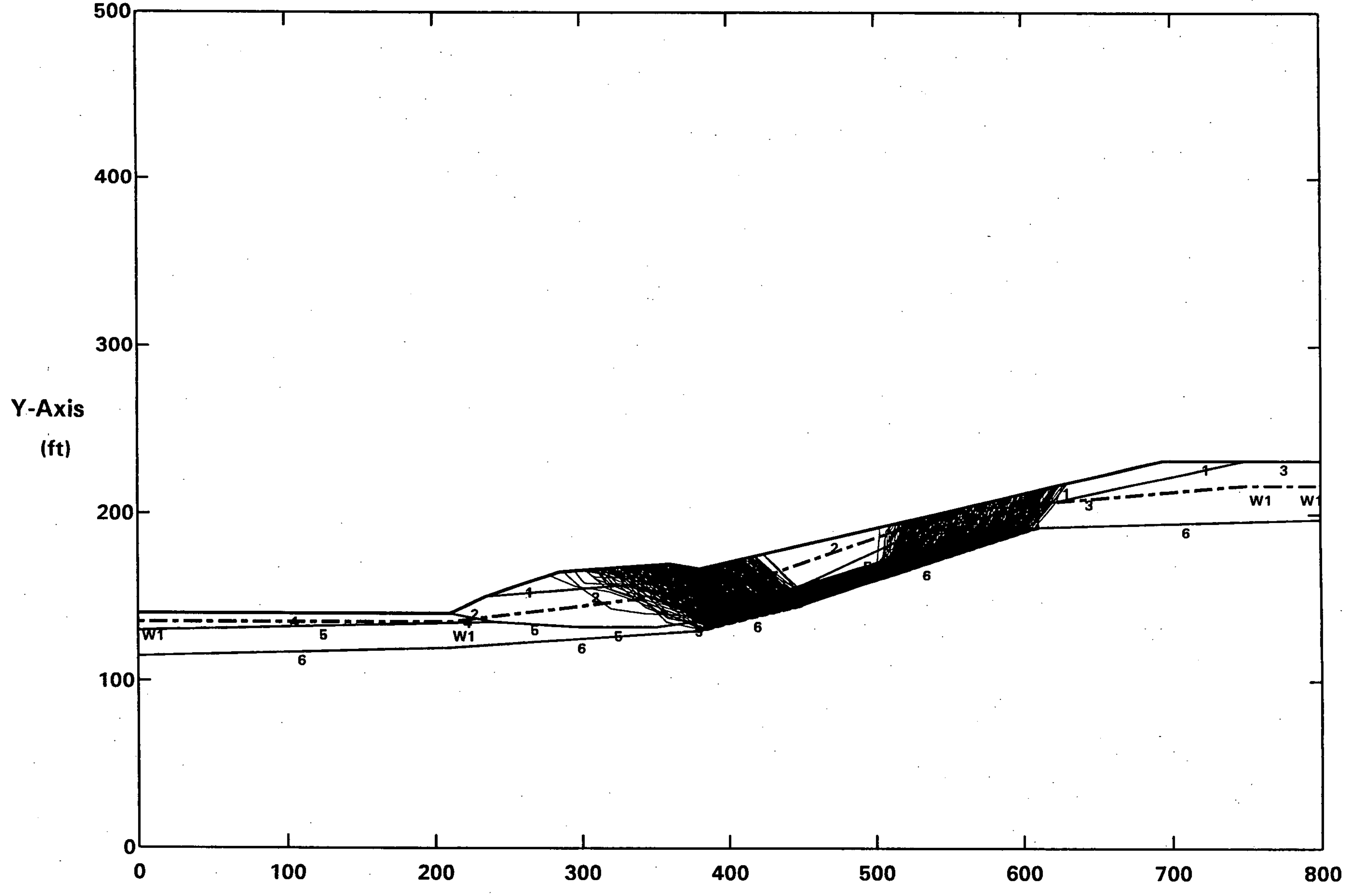


Label	Soil Type No.	Total Unit Wt. (pcf)	Saturated Unit Wt. (pcf)	Cohesion Intercept (psf)	Friction Angle (deg)	Pore Pressure Param.	Pressure Constant (psf)	Piez. Surface No.
WASTE	1	120	125	50	30	0	0	W1
Qc/SLIDE	2	120	125	0	20	0	0	W1
Qrf	3	120	125	0	37	0	0	W1
Qal	4	125	130	0	33	0	0	W1
WCS	5	120	125	0	20	0	0	W1
UCS	6	125	130	600	30	0	0	W1

PCSTABL5M/SI FS = 1.51 Theta = 9.87 X-Axis (ft)
Factors Of Safety Calculated By Spencer`s Method of Slices

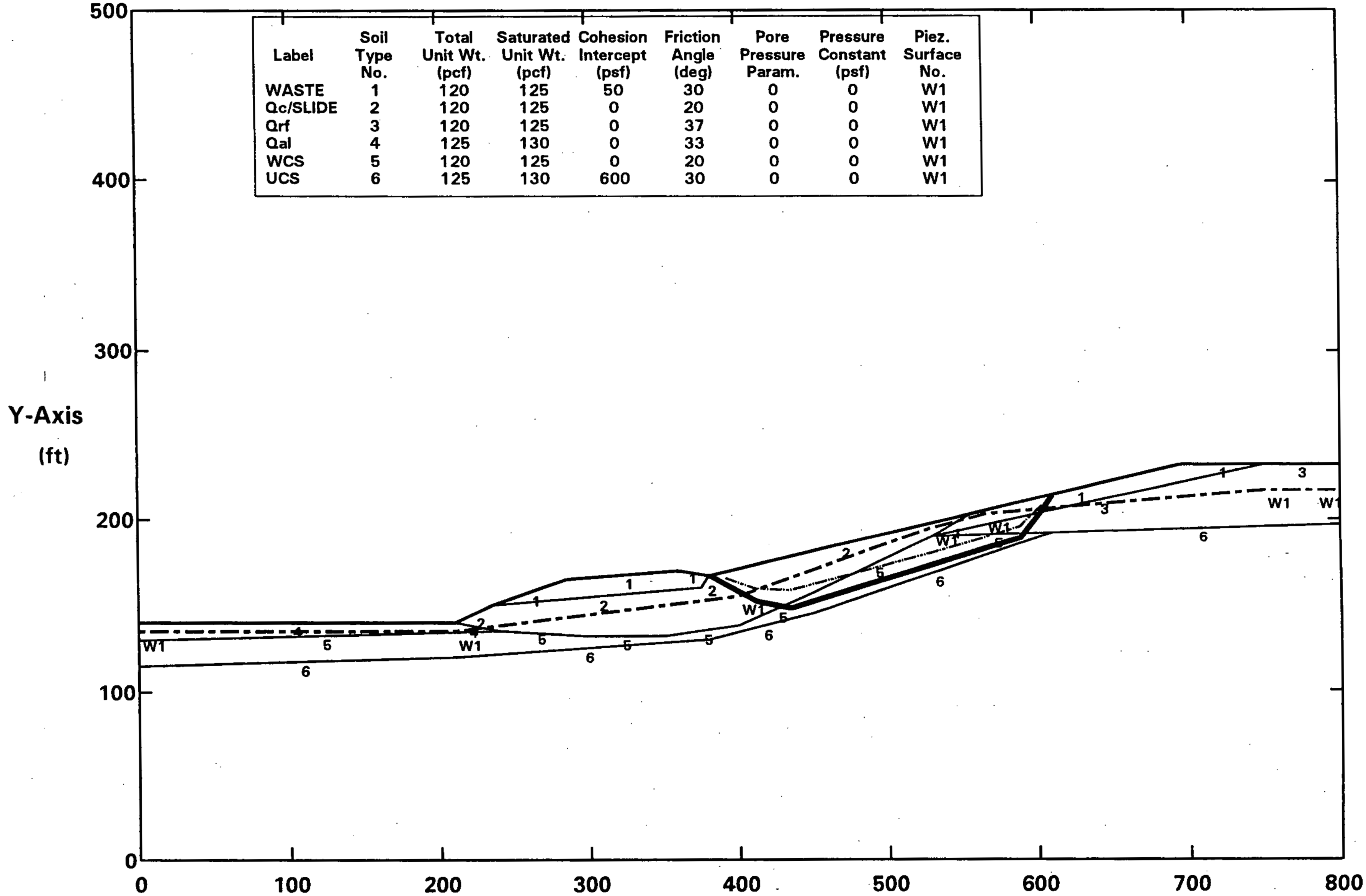
144

ROCKY FLATS OLF - M&E SECTION C - WCS=20 deg - W/HIGHGW - SLIDING BLOCK - STATIC
All surfaces evaluated. C:CEHSS.PLT By: STAN KLINE 10-23-04 7:19pm



Factors Of Safety Calculated By The Modified Janbu Method

ROCKY FLATS OLF - M&E SECTION C - WCS=20 deg - W/HIGHGW - SLIDING BLOCK - STATIC
Surface #1-CEHSS.OUT. C:CEHSSSP.PLT By: STAN KLINE 10-23-04 7:23pm



Label	Soil Type No.	Total Unit Wt. (pcf)	Saturated Unit Wt. (pcf)	Cohesion Intercept (psf)	Friction Angle (deg)	Pore Pressure Param.	Pressure Constant (psf)	Piez. Surface No.
WASTE	1	120	125	50	30	0	0	W1
Qc/SLIDE	2	120	125	0	20	0	0	W1
Qrf	3	120	125	0	37	0	0	W1
Qal	4	125	130	0	33	0	0	W1
WCS	5	120	125	0	20	0	0	W1
UCS	6	125	130	600	30	0	0	W1

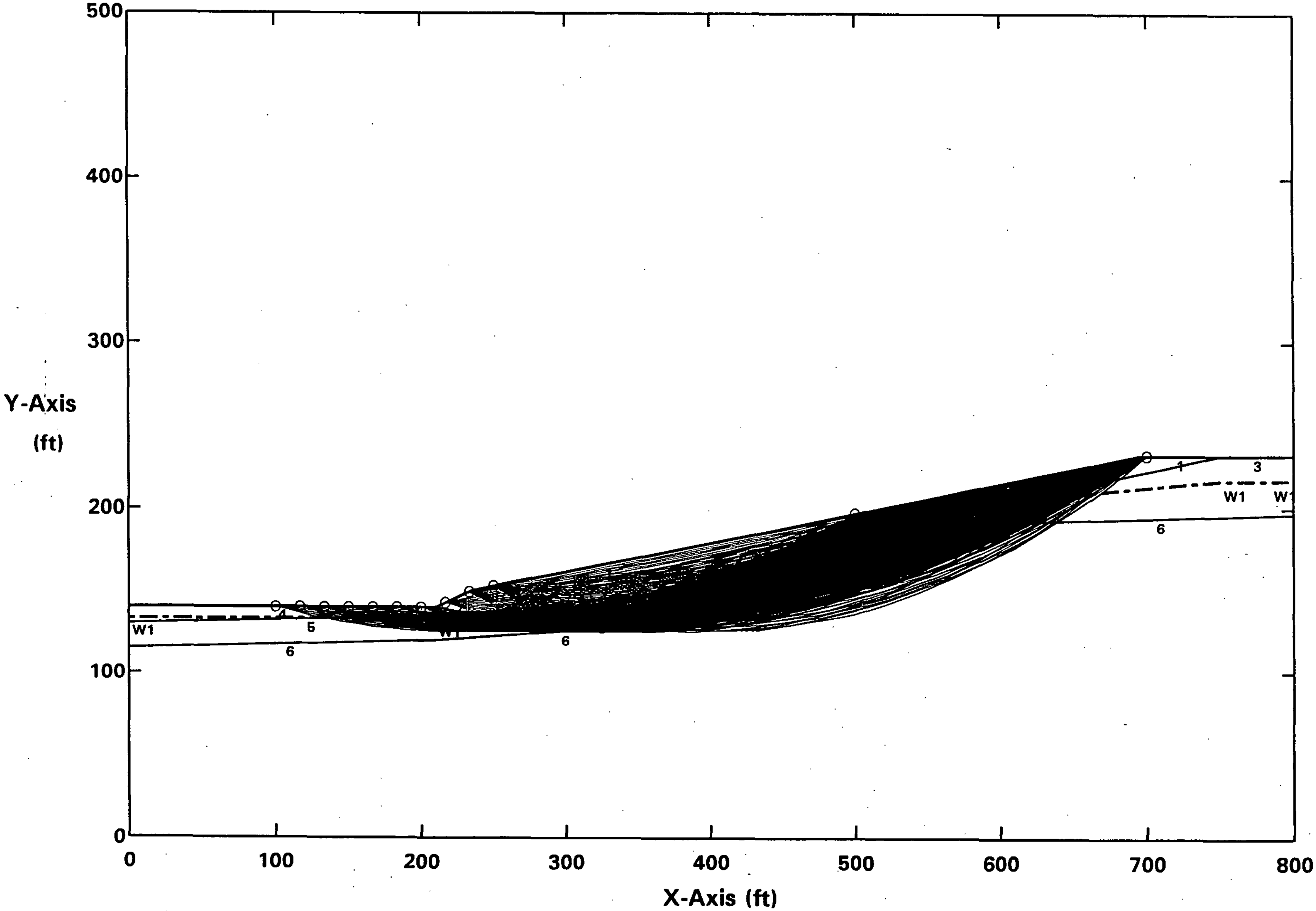
PCSTABL5M/SI FS=1.45 Theta=9.88 X-Axis (ft)
Factors Of Safety Calculated By Spencer`s Method of Slices

18% REGRADE CONDITION

1-16

147

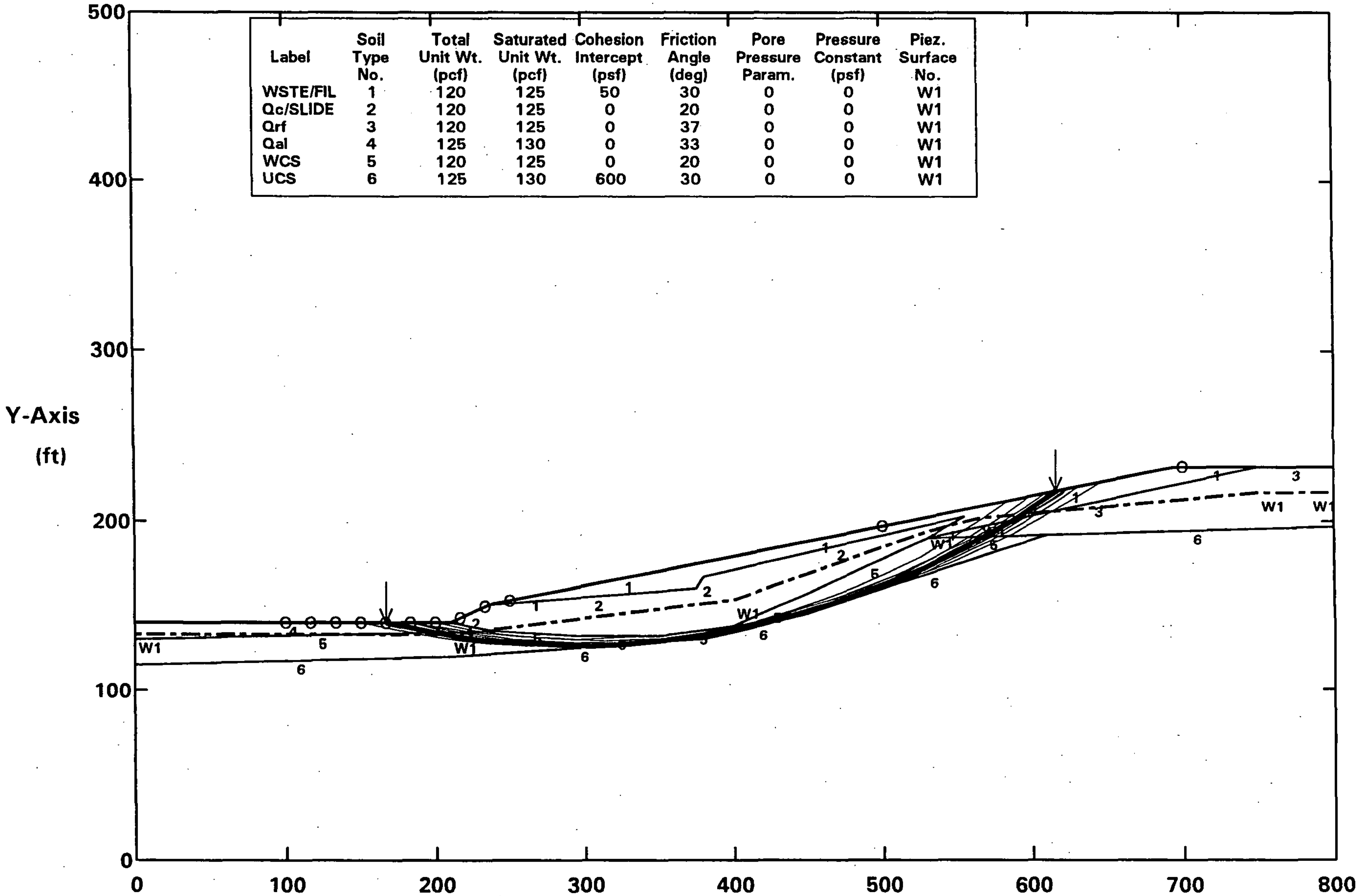
ROCKY FLATS OLF - M&E C 18% GRD - WCS = 20 deg - W/AVEGW - CIRCULAR - STATIC
All surfaces evaluated. C:CGACS.PLT By: STAN KLINE 10-23-04 10:20pm



Factors Of Safety Calculated By The Modified Bishop Method

148

ROCKY FLATS OLF - M&E C 18% GRD - WCS = 20 deg - W/AVEGW - CIRCULAR - STATIC
Ten Most Critical. C:CGACS.PLT By: STAN KLINE 10-23-04 10:20pm

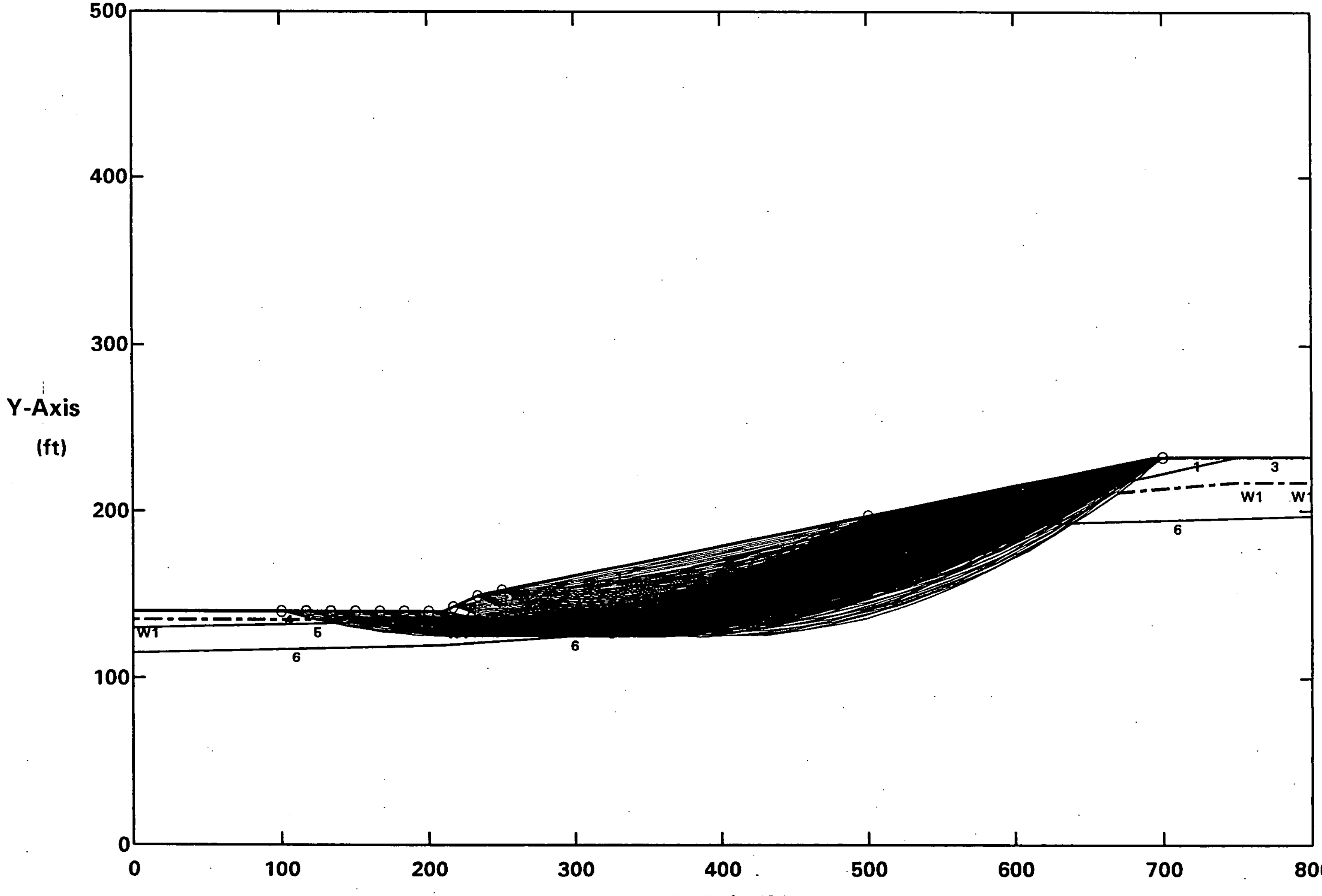


Label	Soil Type No.	Total Unit Wt. (pcf)	Saturated Unit Wt. (pcf)	Cohesion Intercept (psf)	Friction Angle (deg)	Pore Pressure Param.	Pressure Constant (psf)	Piez. Surface No.
WSTE/FIL	1	120	125	50	30	0	0	W1
Qc/SLIDE	2	120	125	0	20	0	0	W1
Qrf	3	120	125	0	37	0	0	W1
Qal	4	125	130	0	33	0	0	W1
WCS	5	120	125	0	20	0	0	W1
UCS	6	125	130	600	30	0	0	W1

PCSTABL5M/SI FSmin = 1.66 X-Axis (ft)
Factors Of Safety Calculated By The Modified Bishop Method

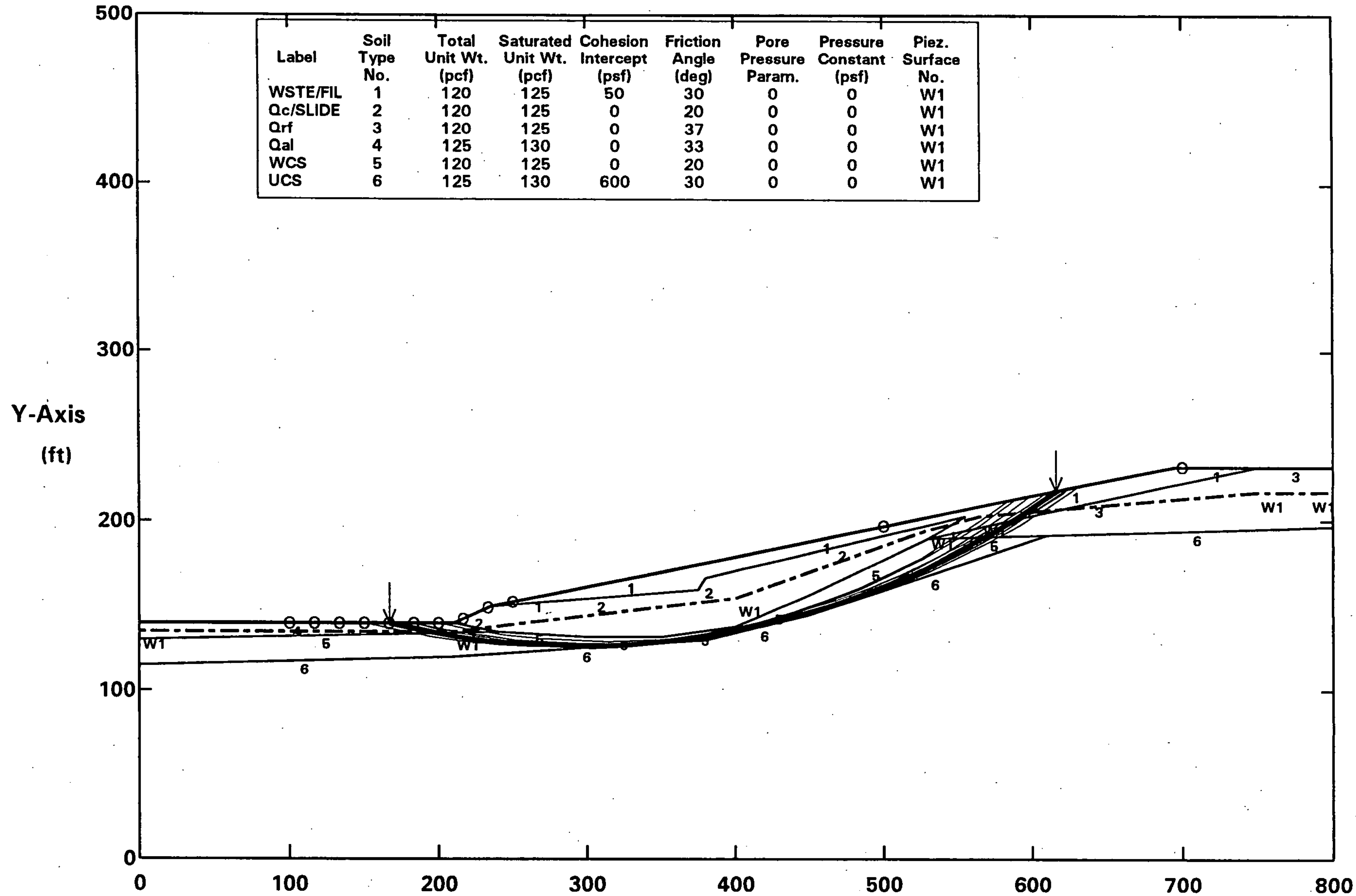
146

ROCKY FLATS OLF - M&E C 18% GRD - WCS = 20 deg - W/HIGHGW - CIRCULAR - STATIC
All surfaces evaluated. C:CGHCS.PLT By: STAN KLINE 10-23-04 9:56pm



Factors Of Safety Calculated By The Modified Bishop Method

ROCKY FLATS OLF - M&E C 18% GRD - WCS = 20 deg - W/HIGHGW - CIRCULAR - STATIC
Ten Most Critical. C:CGHCS.PLT By: STAN KLINE 10-23-04 9:56pm

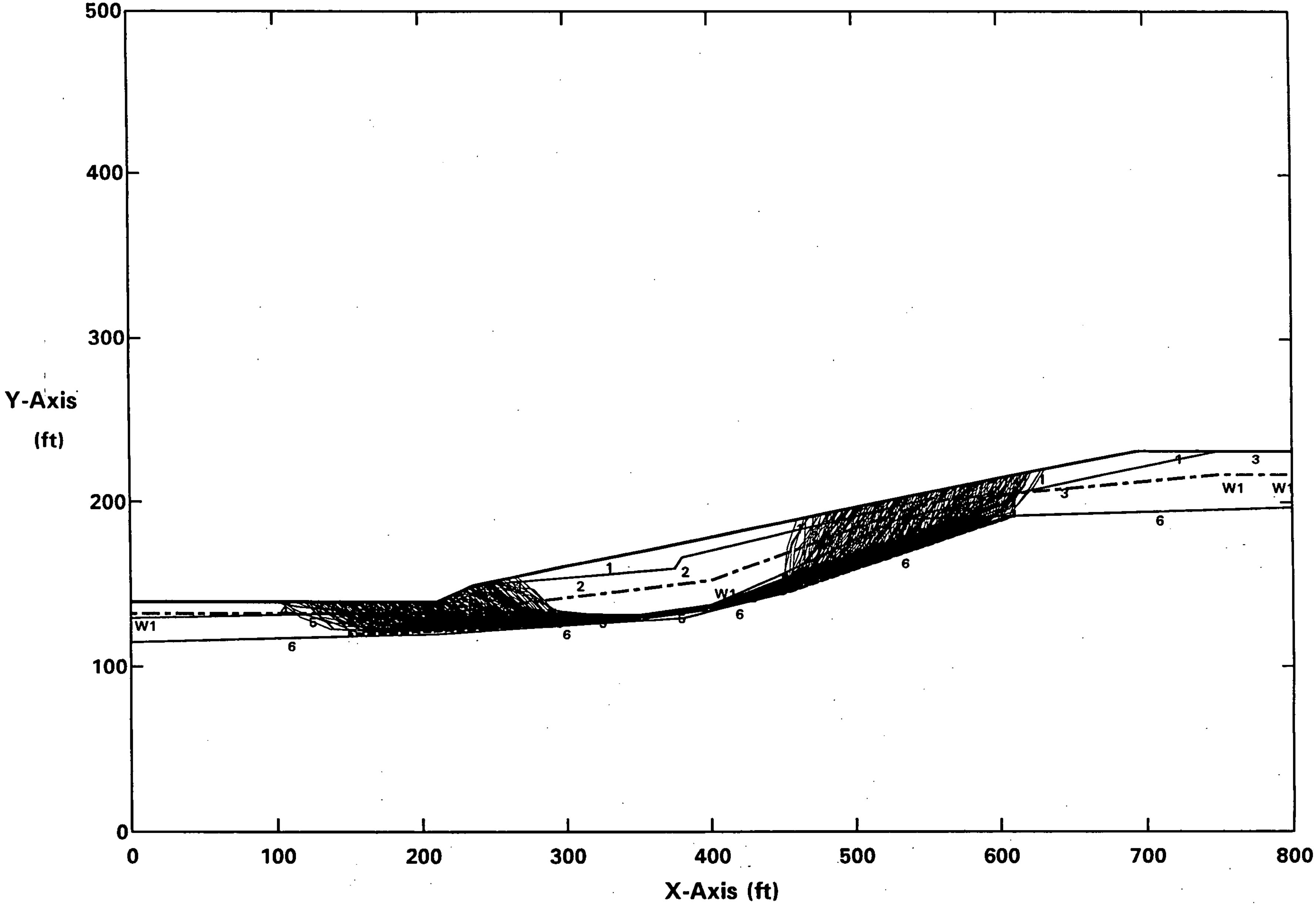


Label	Soil Type No.	Total Unit Wt. (pcf)	Saturated Unit Wt. (pcf)	Cohesion Intercept (psf)	Friction Angle (deg)	Pore Pressure Param.	Pressure Constant (psf)	Piez. Surface No.
WSTE/FIL	1	120	125	50	30	0	0	W1
Qc/SLIDE	2	120	125	0	20	0	0	W1
Qrf	3	120	125	0	37	0	0	W1
Qal	4	125	130	0	33	0	0	W1
WCS	5	120	125	0	20	0	0	W1
UCS	6	125	130	600	30	0	0	W1

PCSTABL5M/SI FSmin = 1.61 X-Axis (ft)
Factors Of Safety Calculated By The Modified Bishop Method

151

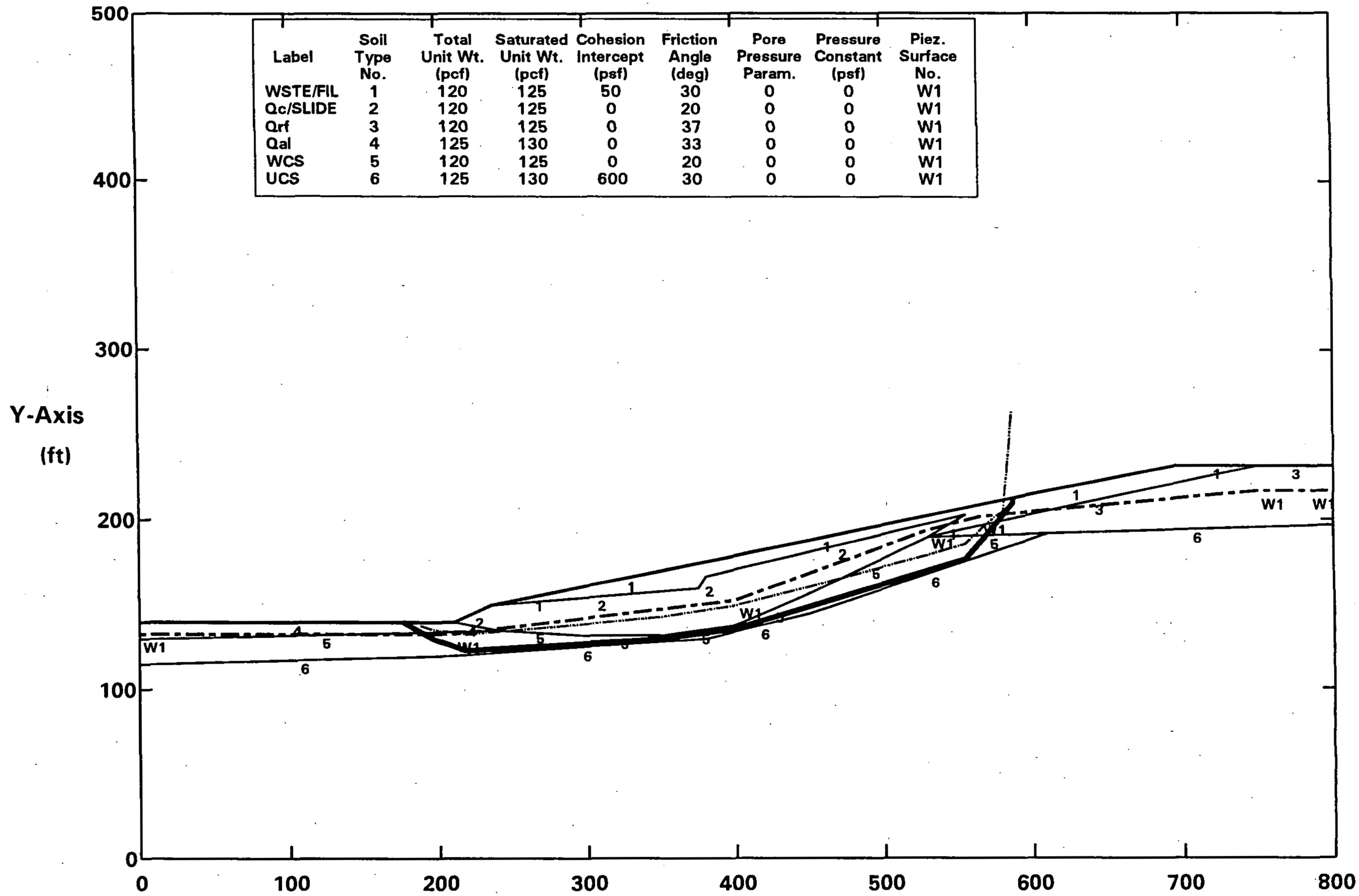
ROCKY FLATS OLF - M&E C 18% GRD - WCS = 20 deg - W/AVEGW - SLIDING BLOCK - STATIC
All surfaces evaluated. C:CGASS.PLT By: STAN KLINE 10-23-04 10:26pm



Factors Of Safety Calculated By The Modified Janbu Method

152

ROCKY FLATS OLF - M&E C 18% GRD - WCS = 20 deg - W/AVEGW - SLIDING BLOCK - STATIC
Surface #1-CGASS.OUT. C:CGASSSP.PLT By: STAN KLINE 10-23-04 10:29pm

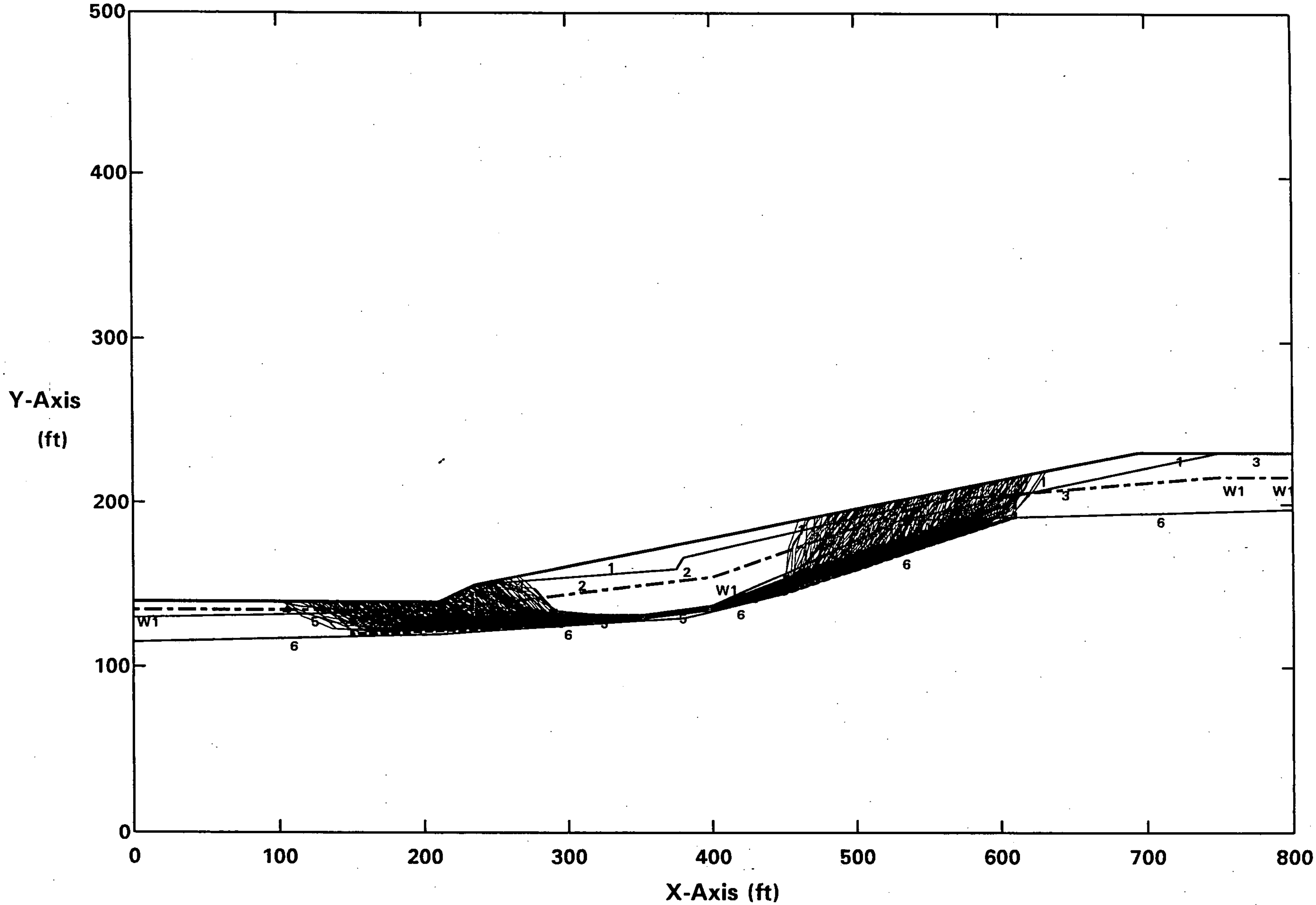


Label	Soil Type No.	Total Unit Wt. (pcf)	Saturated Unit Wt. (pcf)	Cohesion Intercept (psf)	Friction Angle (deg)	Pore Pressure Param.	Pressure Constant (psf)	Piez. Surface No.
WSTE/FIL	1	120	125	50	30	0	0	W1
Qc/SLIDE	2	120	125	0	20	0	0	W1
Qrf	3	120	125	0	37	0	0	W1
Qal	4	125	130	0	33	0	0	W1
WCS	5	120	125	0	20	0	0	W1
UCS	6	125	130	600	30	0	0	W1

PCSTABL5M/SI FS = 1.65 Theta = 9.43 X-Axis (ft)
Factors Of Safety Calculated By Spencer`s Method of Slices

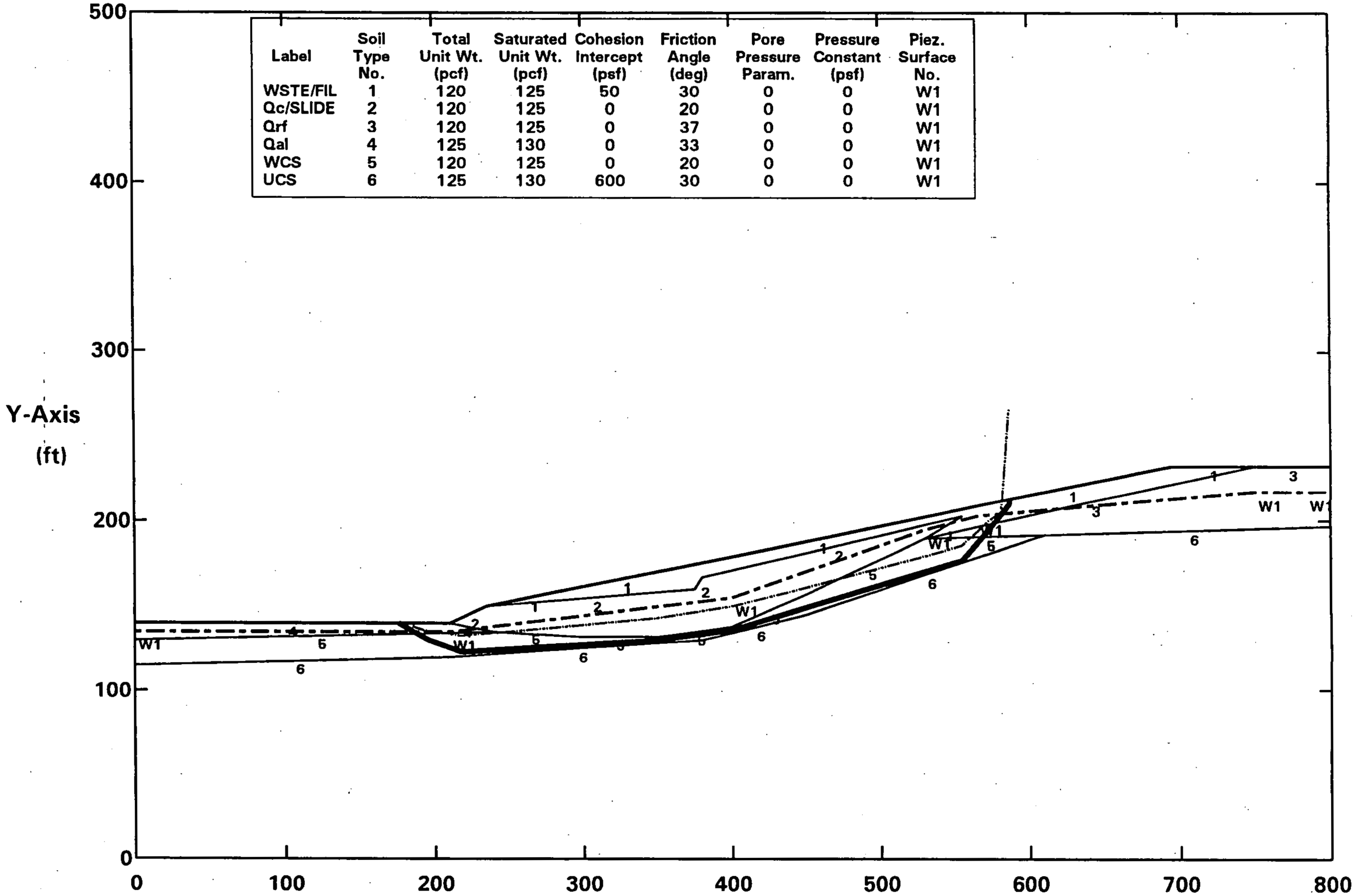
152

ROCKY FLATS OLF - M&E C 18% GRD - WCS=20 deg - W/HIGHGW - SLIDING BLOCK - STATIC
All surfaces evaluated. C:CGHSS.PLT By: STAN KLINE 10-23-04 7:42pm



Factors Of Safety Calculated By The Modified Janbu Method

ROCKY FLATS OLF - M&E C 18% GRD - WCS=20 deg - W/HIGHGW - SLIDING BLOCK - STATIC
Surface #1-CGHSS.OUT. C:CGHSSSP.PLT By: STAN KLINE 10-23-04 8:02pm



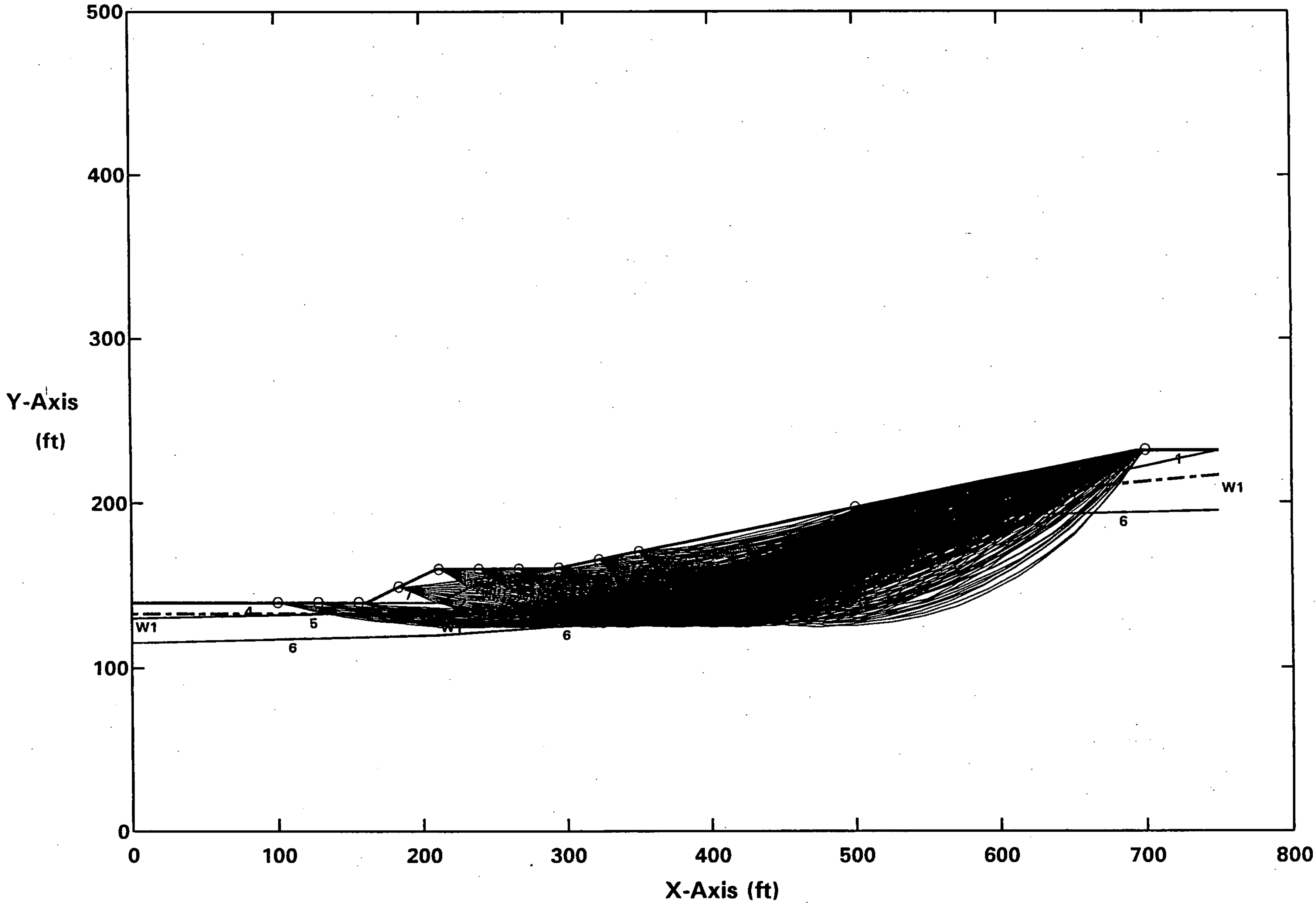
Label	Soil Type No.	Total Unit Wt. (pcf)	Saturated Unit Wt. (pcf)	Cohesion Intercept (psf)	Friction Angle (deg)	Pore Pressure Param.	Pressure Constant (psf)	Piez. Surface No.
WSTE/FIL	1	120	125	50	30	0	0	W1
Qc/SLIDE	2	120	125	0	20	0	0	W1
Qrf	3	120	125	0	37	0	0	W1
Qal	4	125	130	0	33	0	0	W1
WCS	5	120	125	0	20	0	0	W1
UCS	6	125	130	600	30	0	0	W1

PCSTABL5M/SI FS=1.59 Theta=9.46 X-Axis (ft)
Factors Of Safety Calculated By Spencer`s Method of Slices

18% REGRADE WITH BUTTRESS CONDITION

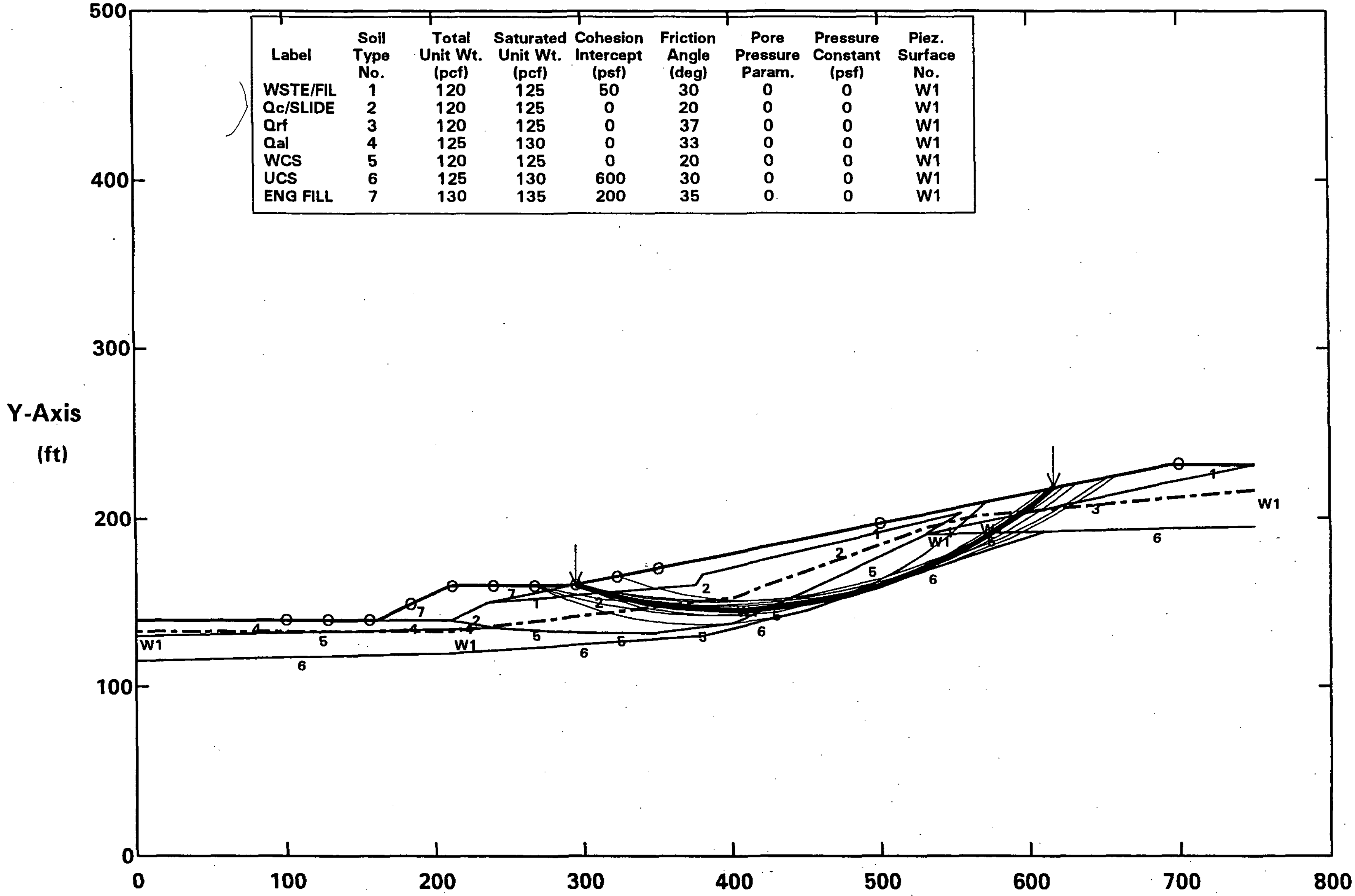
155

ROCKY FLATS OLF - M&E C 18%W/BM - WCS=20 deg - W/AVEGW - CIRCULAR - STATIC
All surfaces evaluated. C:CBACS.PLT By: STAN KLINE 10-23-04 10:22pm



Factors Of Safety Calculated By The Modified Bishop Method

ROCKY FLATS OLF - M&E C 18%W/BM - WCS=20 deg - W/AVEGW - CIRCULAR - STATIC
Ten Most Critical. C:CBACS.PLT By: STAN KLINE 10-23-04 10:22pm

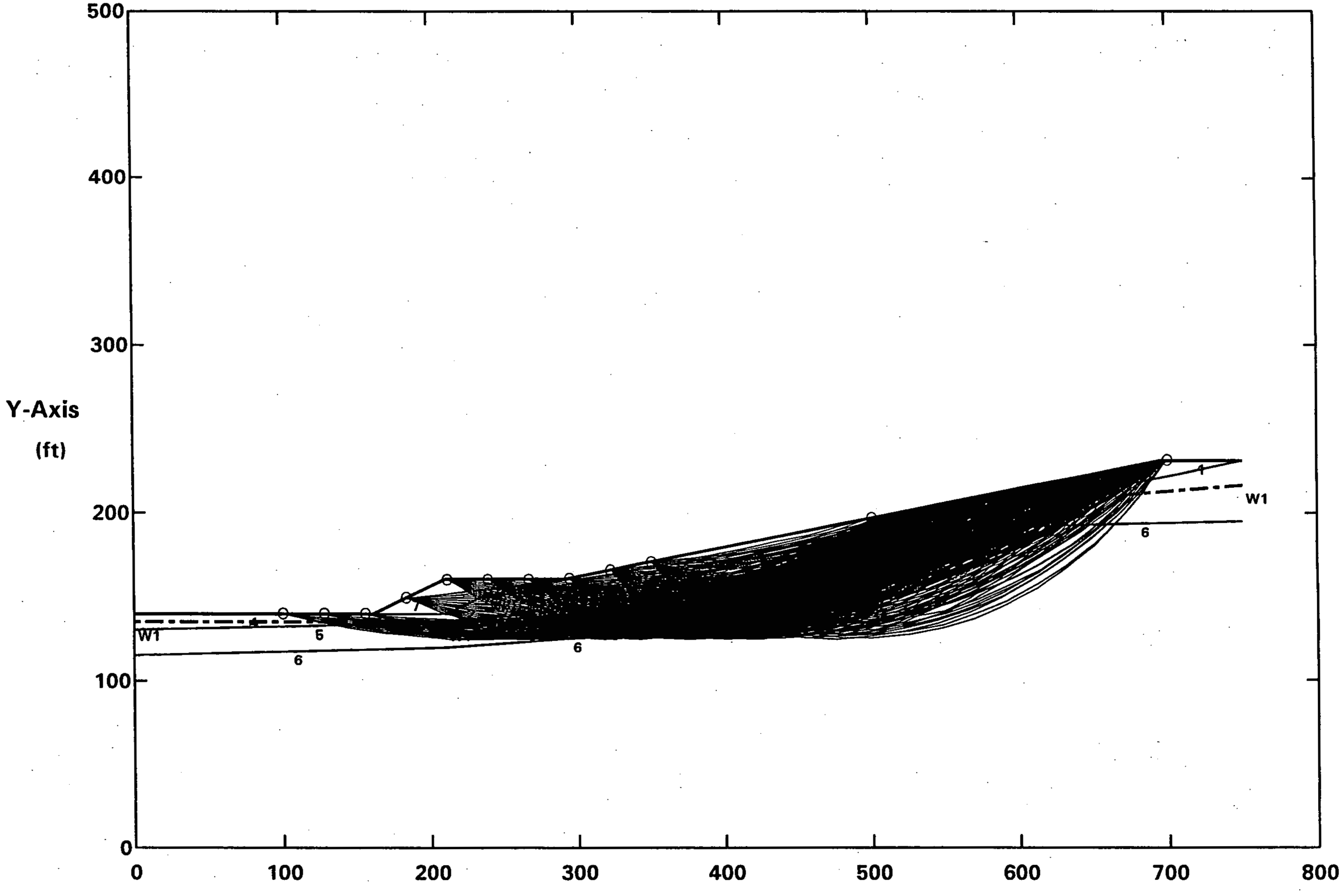


Label	Soil Type No.	Total Unit Wt. (pcf)	Saturated Unit Wt. (pcf)	Cohesion Intercept (psf)	Friction Angle (deg)	Pore Pressure Param.	Pressure Constant (psf)	Piez. Surface No.
WSTE/FIL	1	120	125	50	30	0	0	W1
Qc/SLIDE	2	120	125	0	20	0	0	W1
Qrf	3	120	125	0	37	0	0	W1
Qal	4	125	130	0	33	0	0	W1
WCS	5	120	125	0	20	0	0	W1
UCS	6	125	130	600	30	0	0	W1
ENG FILL	7	130	135	200	35	0	0	W1

PCSTABL5M/SI FSmin=1.83 X-Axis (ft)
Factors Of Safety Calculated By The Modified Bishop Method

158

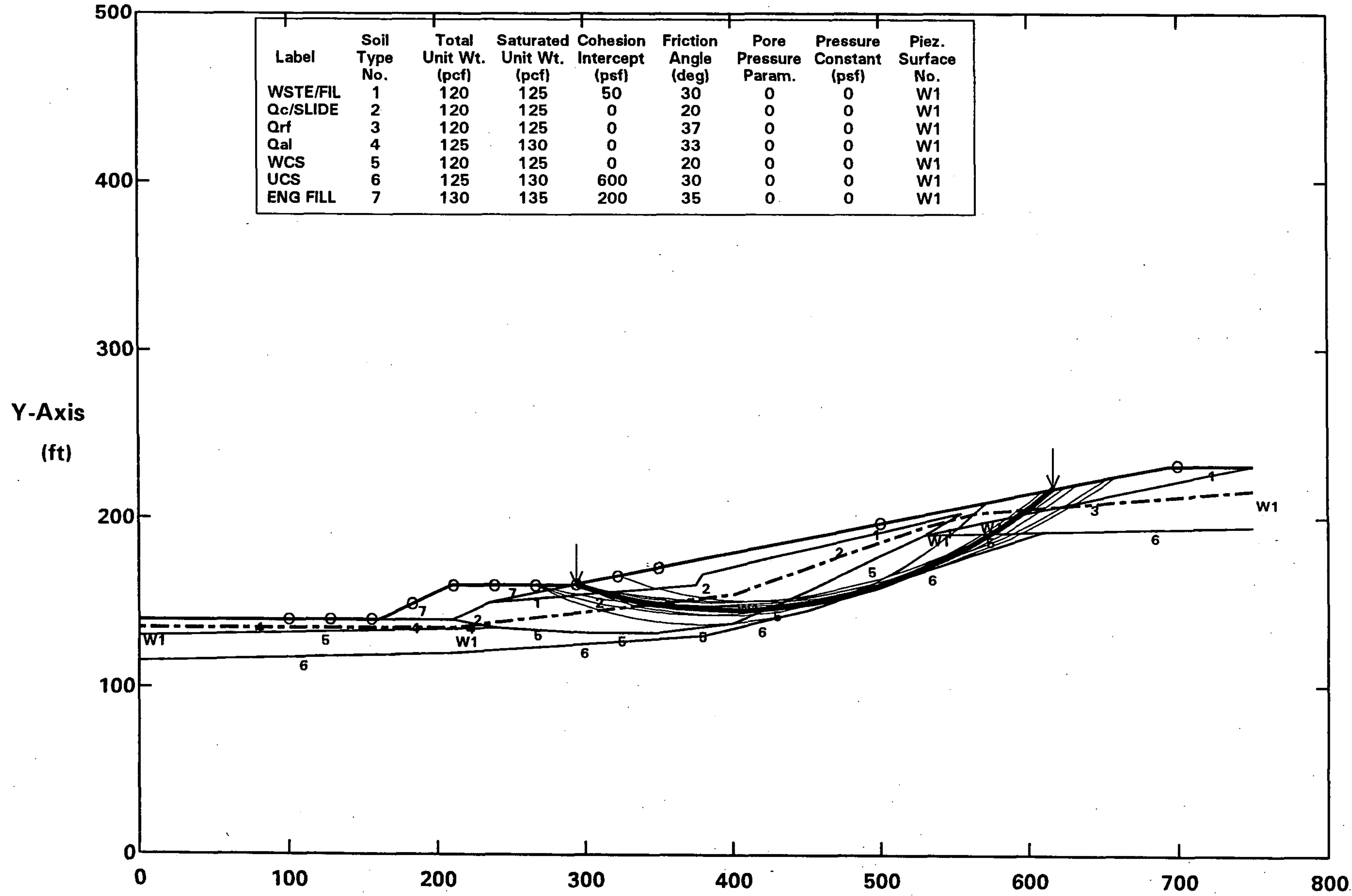
ROCKY FLATS OLF - M&E C 18%W/BM - WCS=20 deg - W/HIGHGW - CIRCULAR - STATIC
All surfaces evaluated. C:CBHCS.PLT By: STAN KLINE 10-23-04 10:03pm



Factors Of Safety Calculated By The Modified Bishop Method

159

ROCKY FLATS OLF - M&E C 18%W/BM - WCS = 20 deg - W/HIGHGW - CIRCULAR - STATIC
Ten Most Critical. C:CBHCS.PLT By: STAN KLINE 10-23-04 10:03pm



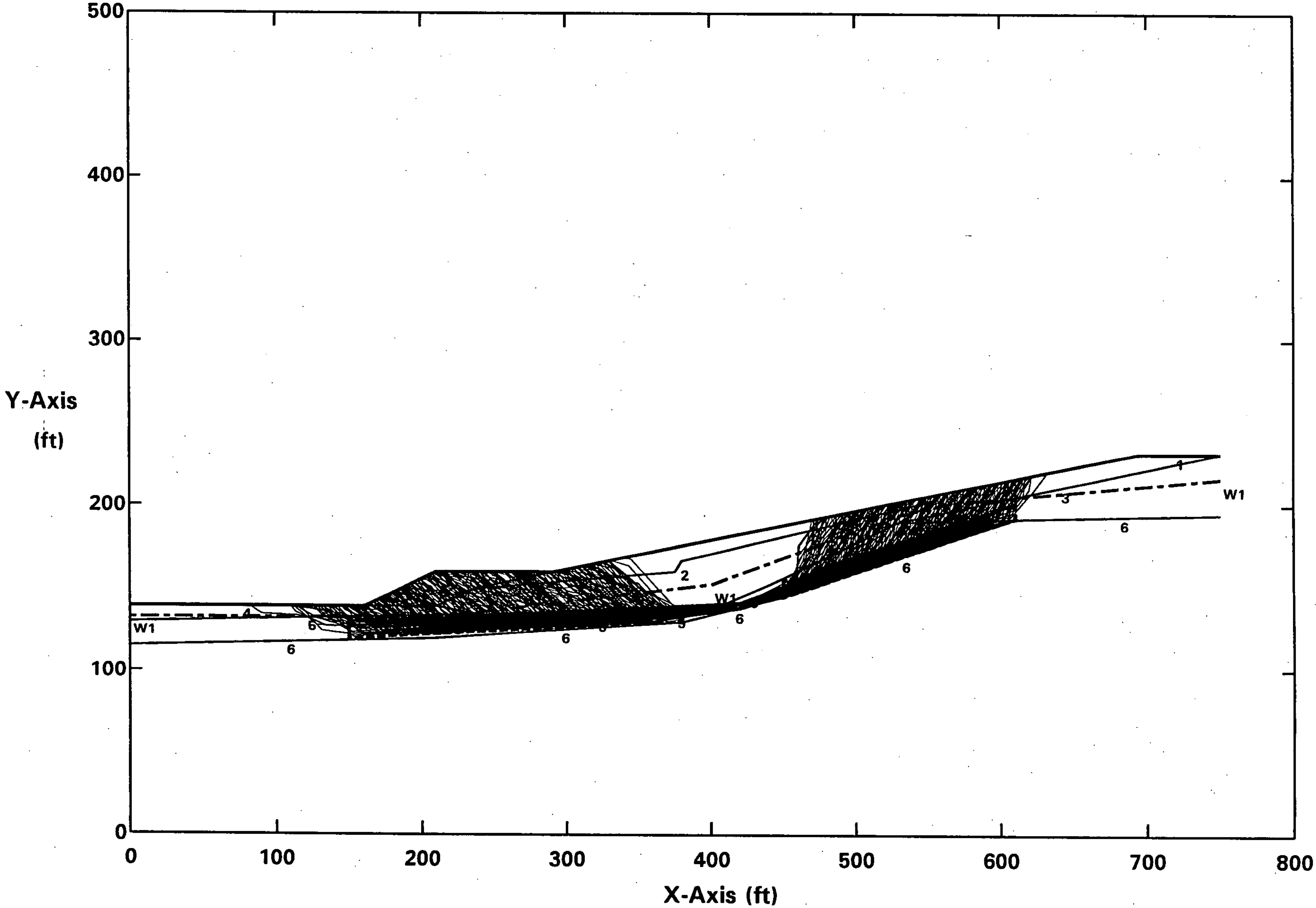
Label	Soil Type No.	Total Unit Wt. (pcf)	Saturated Unit Wt. (pcf)	Cohesion Intercept (psf)	Friction Angle (deg)	Pore Pressure Param.	Pressure Constant (psf)	Piez. Surface No.
WSTE/FIL	1	120	125	50	30	0	0	W1
Qc/SLIDE	2	120	125	0	20	0	0	W1
Qrf	3	120	125	0	37	0	0	W1
Qal	4	125	130	0	33	0	0	W1
WCS	5	120	125	0	20	0	0	W1
UCS	6	125	130	600	30	0	0	W1
ENG FILL	7	130	135	200	35	0	0	W1

PCSTABL5M/SI FSmin = 1.78 X-Axis (ft)

Factors Of Safety Calculated By The Modified Bishop Method

/60

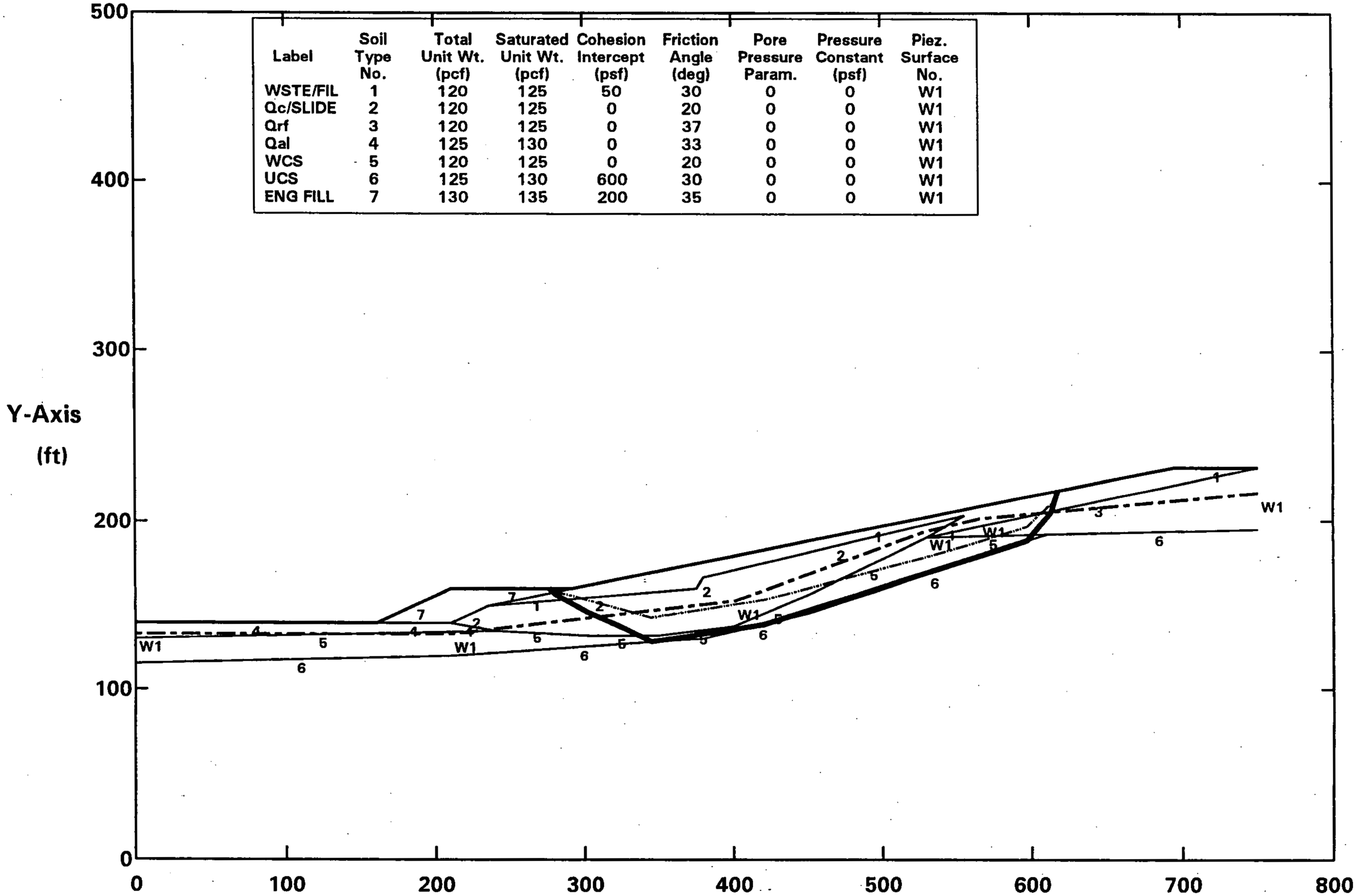
ROCKY FLATS OLF - M&E C 18%W/BM - WCS=20 deg - W/AVEGW - SLIDING BLOCK - STATIC
All surfaces evaluated. C:CBASS.PLT By: STAN KLINE 10-23-04 10:31pm



Factors Of Safety Calculated By The Modified Janbu Method

161

ROCKY FLATS OLF - M&E C 18%W/BM - WCS=20 deg - W/AVEGW - SLIDING BLOCK - STATIC
Surface #1-CBASS.OUT. C:CBASSSP.PLT By: STAN KLINE 10-23-04 10:33pm

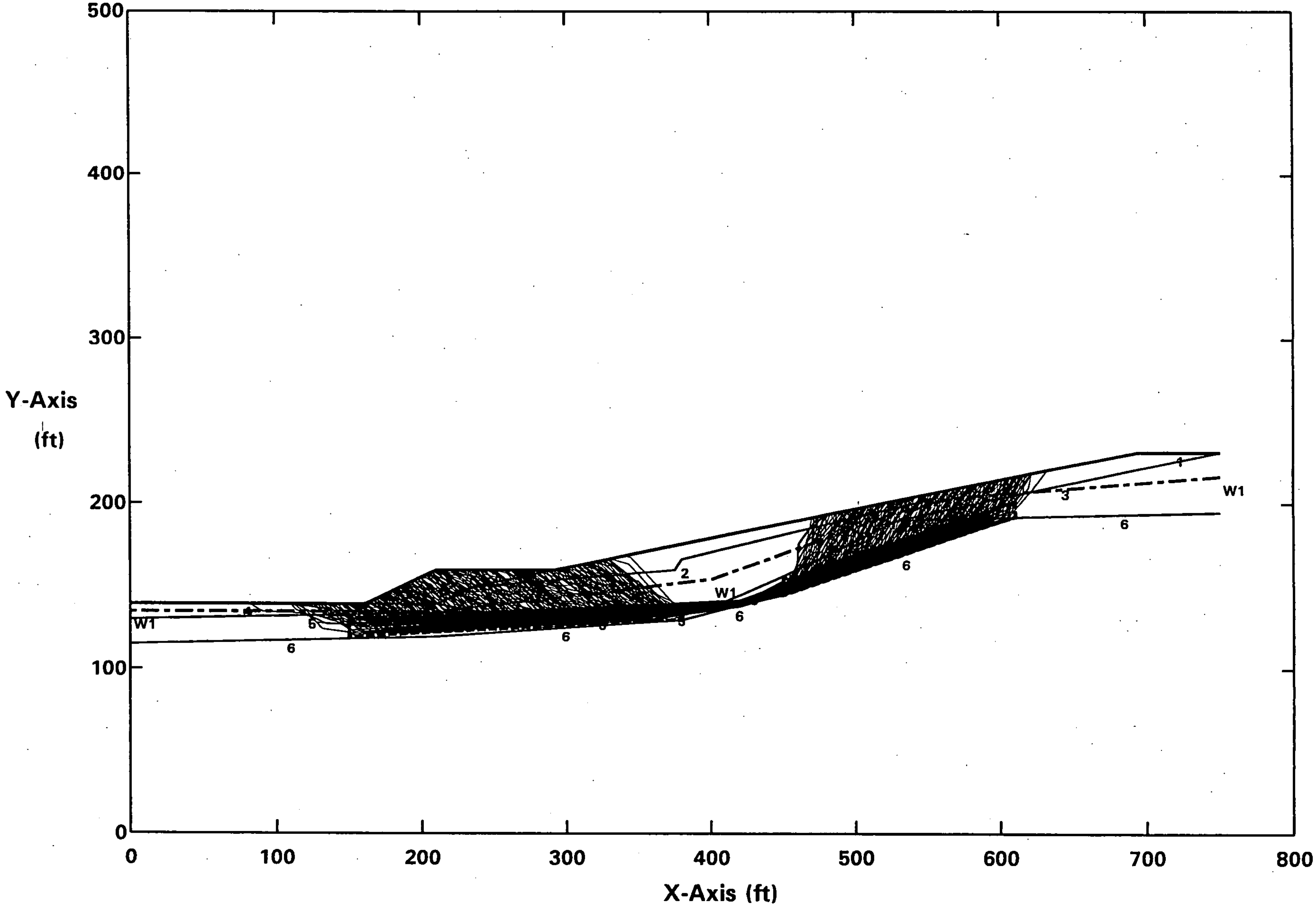


Label	Soil Type No.	Total Unit Wt. (pcf)	Saturated Unit Wt. (pcf)	Cohesion Intercept (psf)	Friction Angle (deg)	Pore Pressure Param.	Pressure Constant (psf)	Piez. Surface No.
WSTE/FIL	1	120	125	50	30	0	0	W1
Qc/SLIDE	2	120	125	0	20	0	0	W1
Qrf	3	120	125	0	37	0	0	W1
Qal	4	125	130	0	33	0	0	W1
WCS	5	120	125	0	20	0	0	W1
UCS	6	125	130	600	30	0	0	W1
ENG FILL	7	130	135	200	35	0	0	W1

PCSTABL5M/SI FS=1.87 Theta=8.57 X-Axis (ft)
Factors Of Safety Calculated By Spencer`s Method of Slices

162

ROCKY FLATS OLF - M&E C 18%W/BM - WCS=20 deg - W/HIGHGW - SLIDING BLOCK - STATIC
All surfaces evaluated. C:CBHSS.PLT By: STAN KLINE 10-23-04 9:01pm

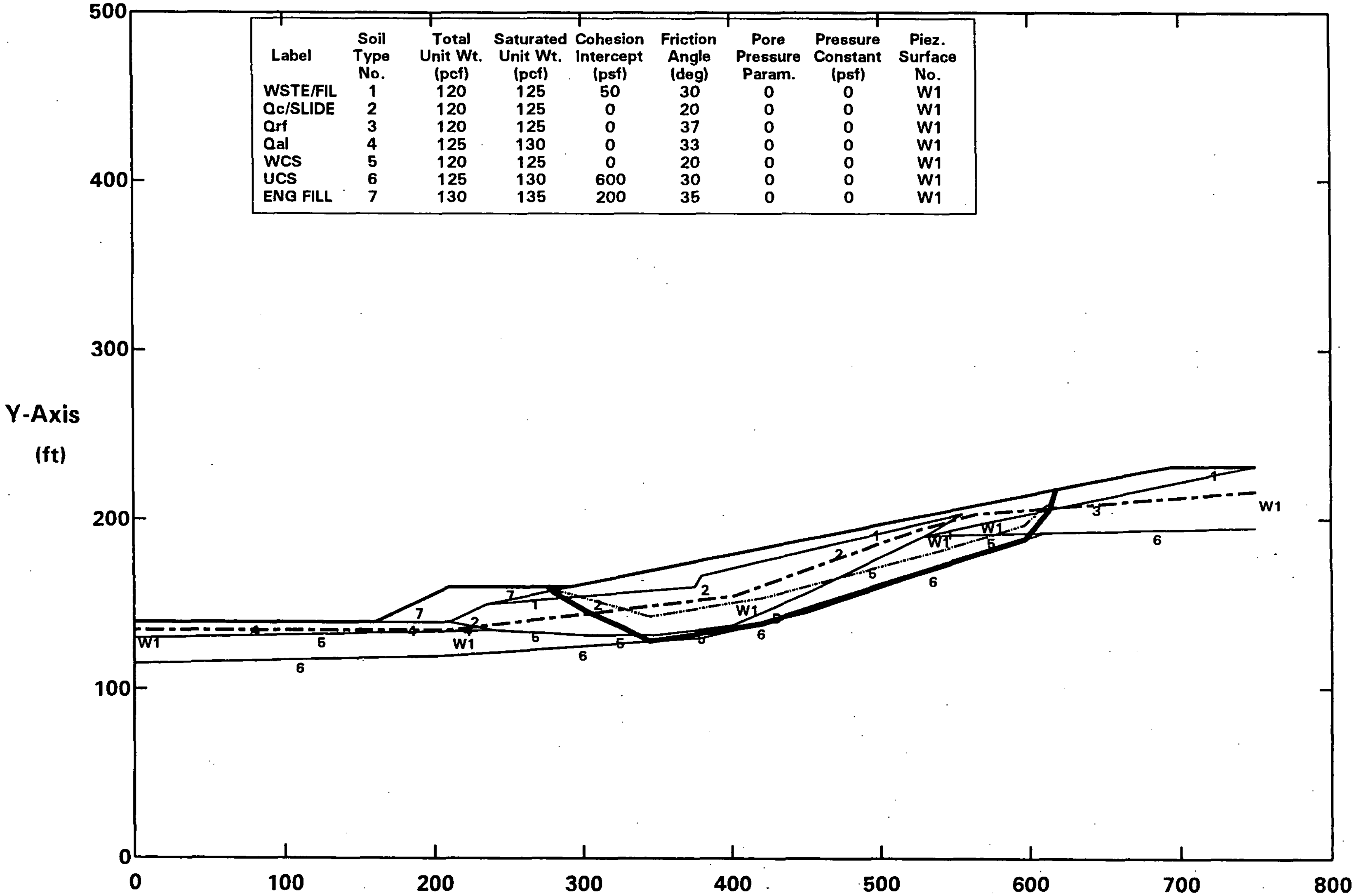


Factors Of Safety Calculated By The Modified Janbu Method

163

ROCKY FLATS OLF - M&E C 18%W/BM - WCS=20 deg - W/HIGHGW - SLIDING BLOCK - STATIC
Surface #1-CBHSS.OUT. C:CBHSSSP.PLT By: STAN KLINE 10-23-04 9:03pm

Label	Soil Type No.	Total Unit Wt. (pcf)	Saturated Unit Wt. (pcf)	Cohesion Intercept (psf)	Friction Angle (deg)	Pore Pressure Param.	Pressure Constant (psf)	Piez. Surface No.
WSTE/FIL	1	120	125	50	30	0	0	W1
Qc/SLIDE	2	120	125	0	20	0	0	W1
Qrf	3	120	125	0	37	0	0	W1
Qal	4	125	130	0	33	0	0	W1
WCS	5	120	125	0	20	0	0	W1
UCS	6	125	130	600	30	0	0	W1
ENG FILL	7	130	135	200	35	0	0	W1



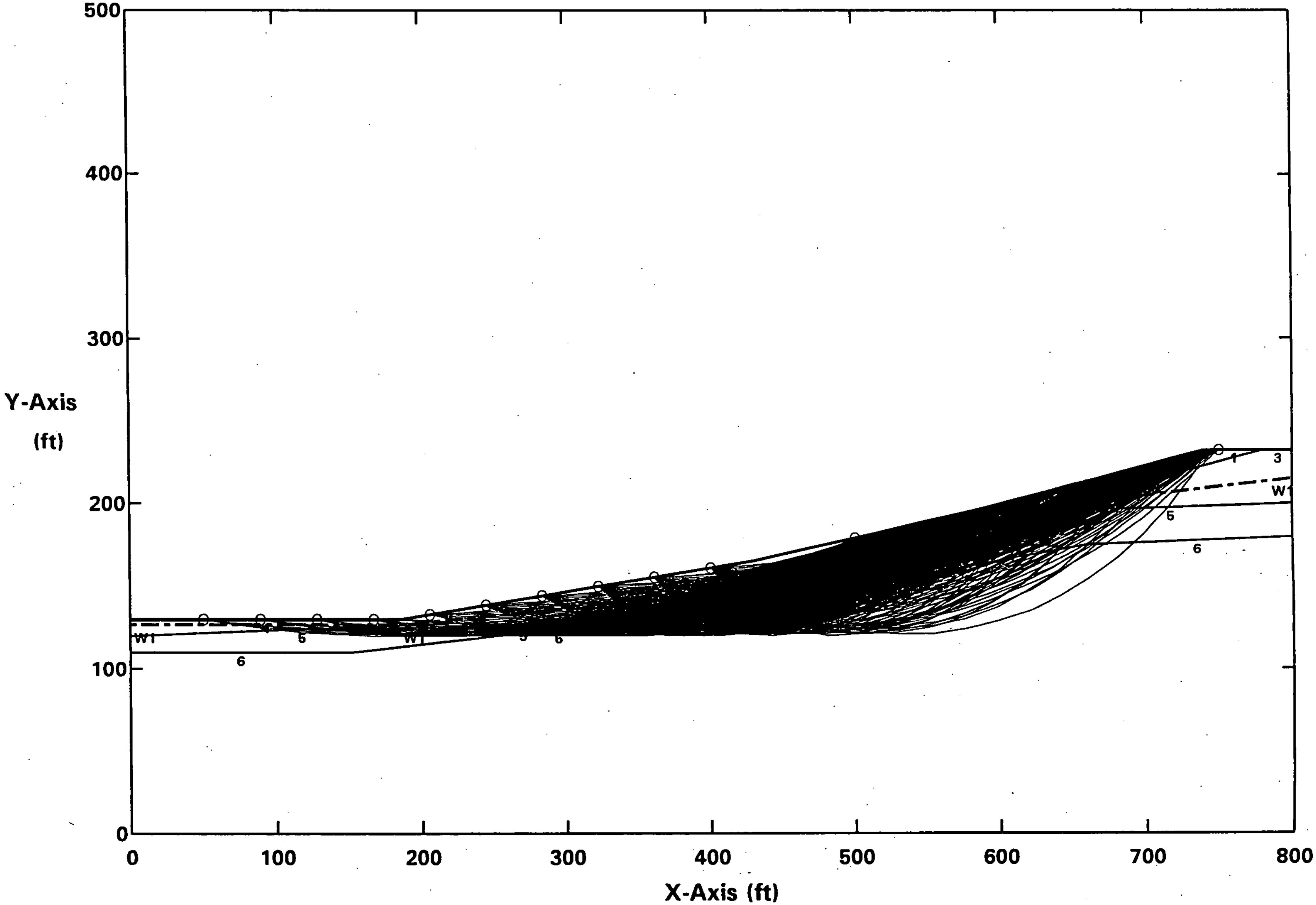
PCSTABL5M/SI FS=1.82 Theta=8.55 X-Axis (ft)
Factors Of Safety Calculated By Spencer`s Method of Slices

M&E SECTION D-D' – STATIC

164

162

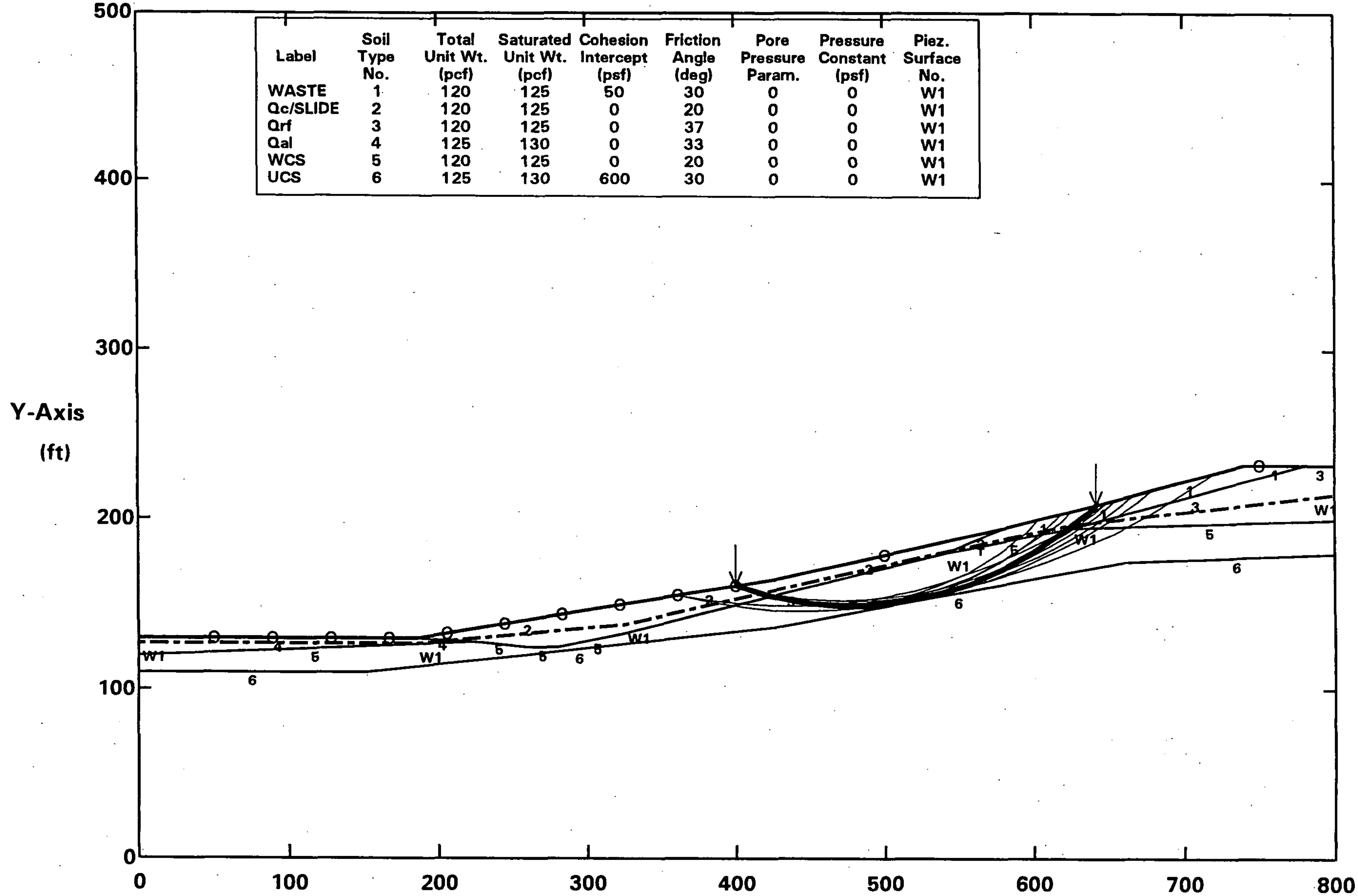
ROCKY FLATS OLF - M&E SECTION D - WCS = 20 deg - W/AVEGW - CIRCULAR - STATIC
All surfaces evaluated. C:DEACS.PLT By: STAN KLINE 10-24-04 2:08am



Factors Of Safety Calculated By The Modified Bishop Method

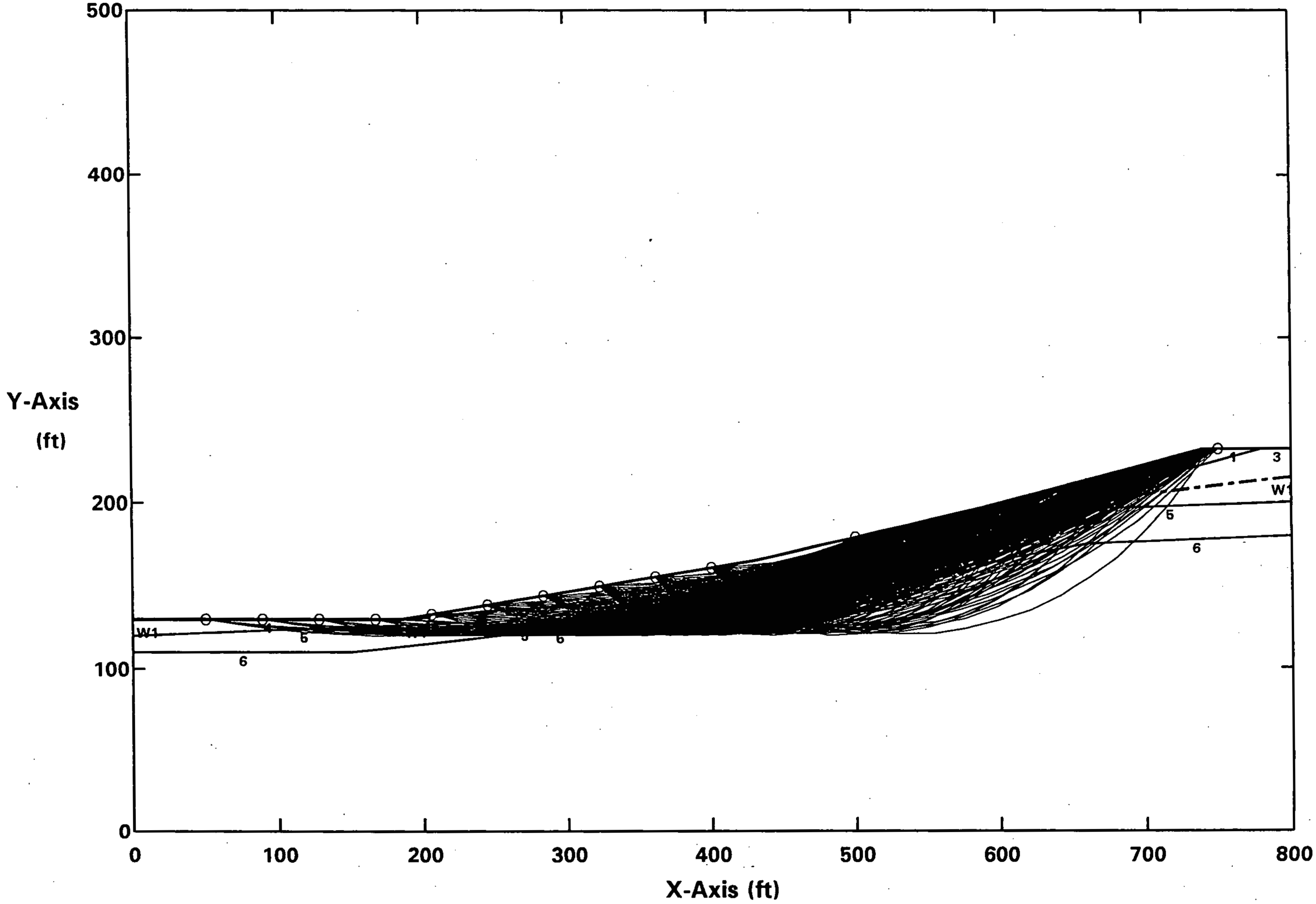
ROCKY FLATS OLF - M&E SECTION D - WCS = 20 deg - W/AVEGW - CIRCULAR - STATIC
Ten Most Critical. C:DEACS.PLT By: STAN KLINE 10-24-04 2:08am

Label	Soil Type No.	Total Unit Wt. (pcf)	Saturated Unit Wt. (pcf)	Cohesion Intercept (psf)	Friction Angle (deg)	Pore Pressure Param.	Pressure Constant (psf)	Piez. Surface No.
WASTE	1	120	125	50	30	0	0	W1
Qc/SLIDE	2	120	125	0	20	0	0	W1
Qrf	3	120	125	0	37	0	0	W1
Qal	4	125	130	0	33	0	0	W1
WCS	5	120	125	0	20	0	0	W1
UCS	6	125	130	600	30	0	0	W1



PCSTABL5M/SI FSmin = 1.31 X-Axis (ft)
Factors Of Safety Calculated By The Modified Bishop Method

ROCKY FLATS OLF - M&E SECTION D - WCS=20 deg - W/HIGHGW - CIRCULAR - STATIC
All surfaces evaluated. C:DEHCS.PLT By: STAN KLINE 10-24-04 12:58am

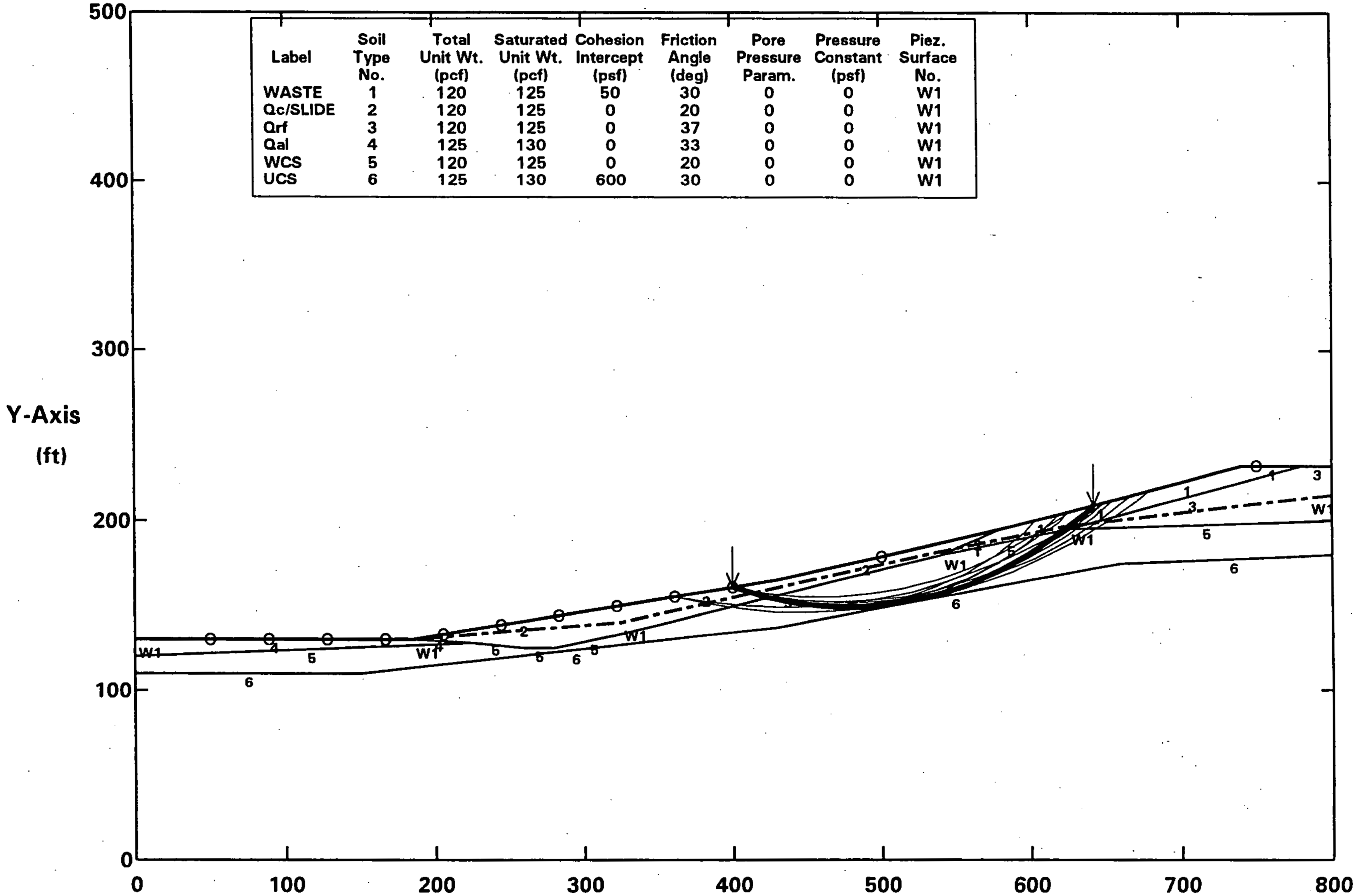


Factors Of Safety Calculated By The Modified Bishop Method

166

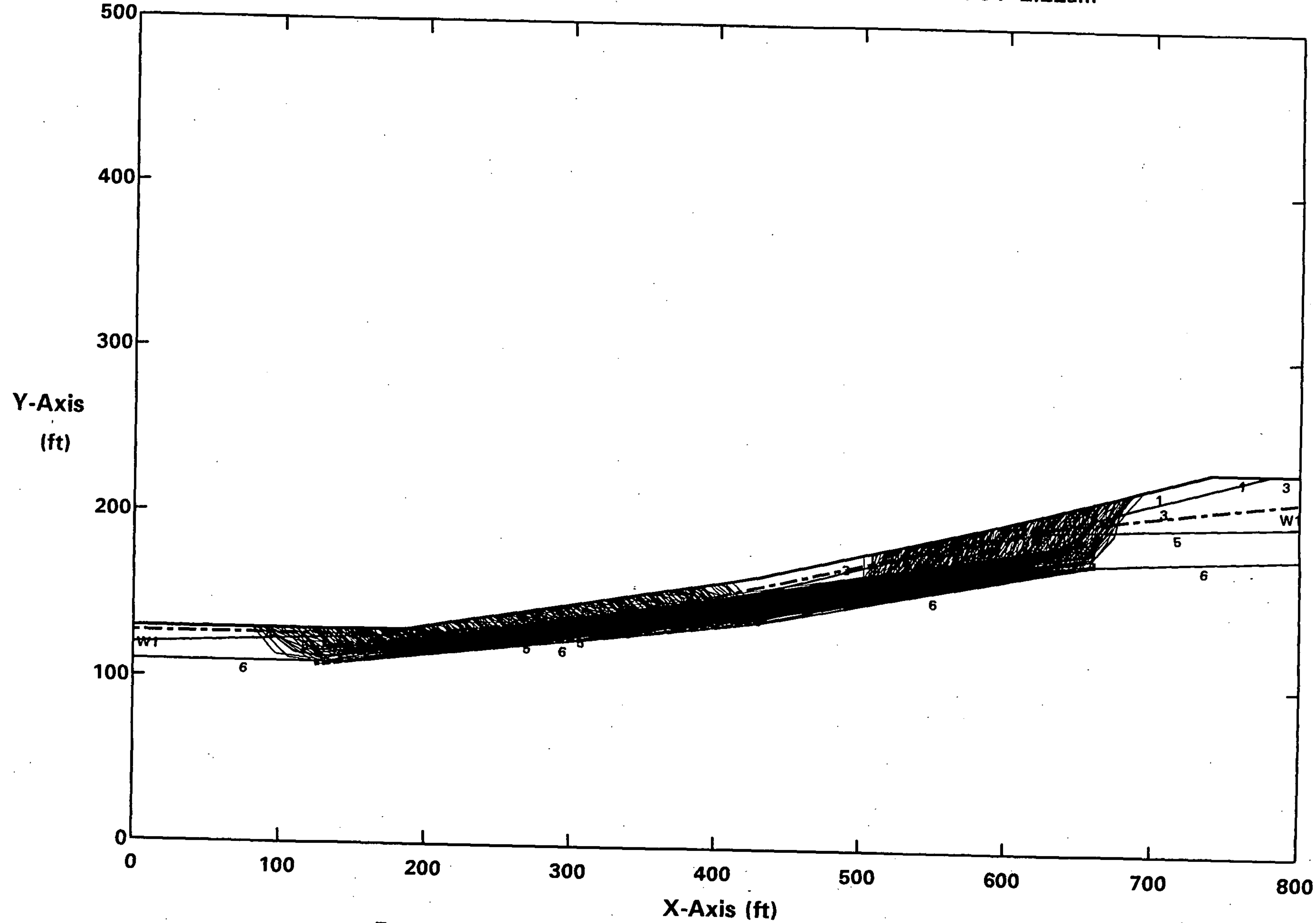
ROCKY FLATS OLF - M&E SECTION D - WCS = 20 deg - W/HIGHGW - CIRCULAR - STATIC
Ten Most Critical. C:DEHCS.PLT By: STAN KLINE 10-24-04 12:58am

Label	Soil Type No.	Total Unit Wt. (pcf)	Saturated Unit Wt. (pcf)	Cohesion Intercept (psf)	Friction Angle (deg)	Pore Pressure Param.	Pressure Constant (psf)	Piez. Surface No.
WASTE	1	120	125	50	30	0	0	W1
Qc/SLIDE	2	120	125	0	20	0	0	W1
Qrf	3	120	125	0	37	0	0	W1
Qal	4	125	130	0	33	0	0	W1
WCS	5	120	125	0	20	0	0	W1
UCS	6	125	130	600	30	0	0	W1



PCSTABL5M/SI FSmin = 1.26 X-Axis (ft)
Factors Of Safety Calculated By The Modified Bishop Method

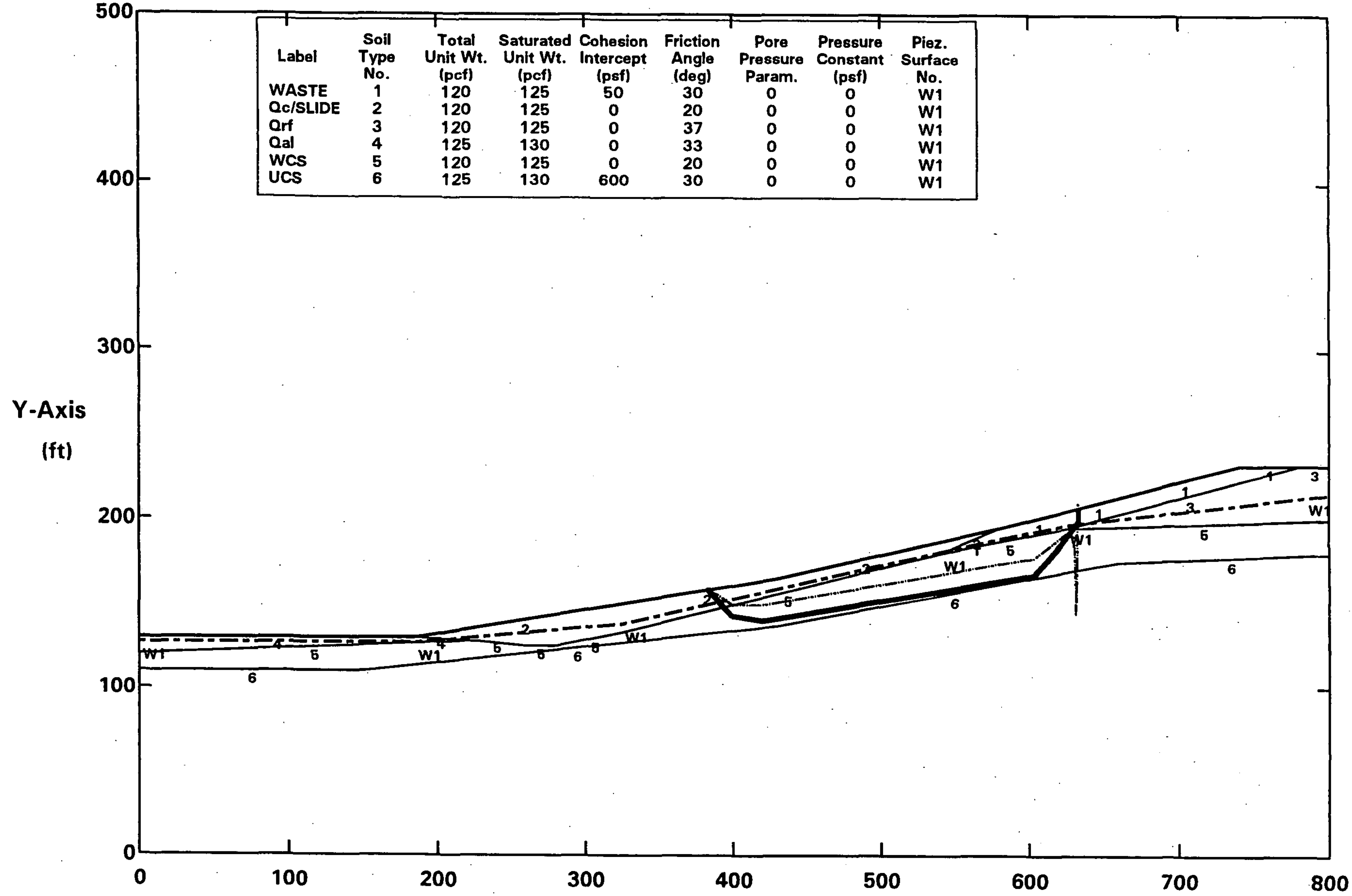
ROCKY FLATS OLF - M&E SECTION D - WCS=20 deg - W/AVEGW - SLIDING BLOCK - STATIC
All surfaces evaluated. C:DEASS.PLT By: STAN KLINE 10-24-04 2:22am



Factors Of Safety Calculated By The Modified Janbu Method

ROCKY FLATS OLF - M&E SECTION D - WCS = 20 deg - W/AVEGW - SLIDING BLOCK - STATIC

Surface #1-DEASS.OUT. C:DEASSSP.PLT By: STAN KLINE 10-24-04 2:22am



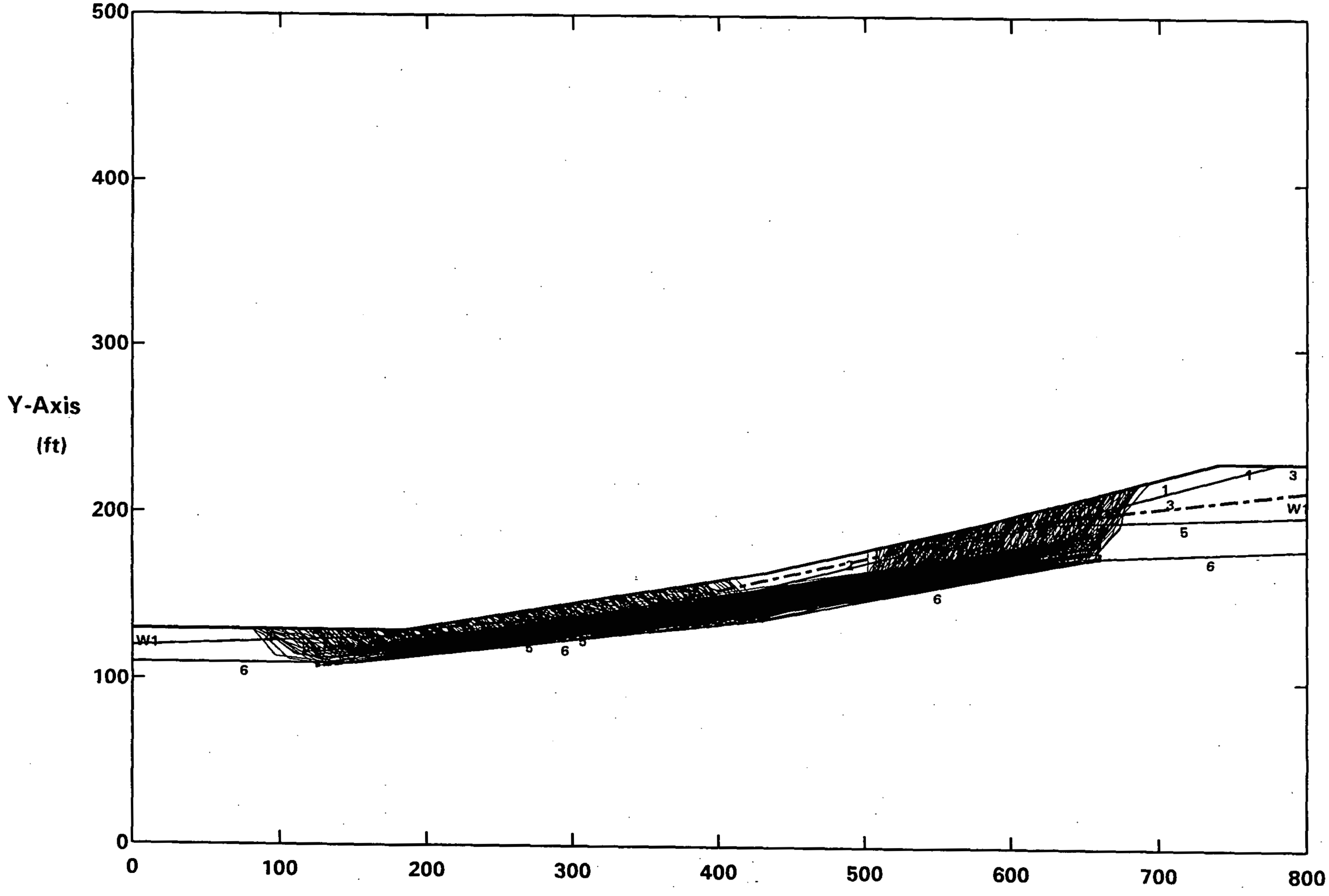
Label	Soil Type No.	Total Unit Wt. (pcf)	Saturated Unit Wt. (pcf)	Cohesion Intercept (psf)	Friction Angle (deg)	Pore Pressure Param.	Pressure Constant (psf)	Piez. Surface No.
WASTE	1	120	125	50	30	0	0	W1
Qc/SLIDE	2	120	125	0	20	0	0	W1
Qrf	3	120	125	0	37	0	0	W1
Qal	4	125	130	0	33	0	0	W1
WCS	5	120	125	0	20	0	0	W1
UCS	6	125	130	600	30	0	0	W1

PCSTABL5M/SI FS = 1.45 Theta = 8.89 X-Axis (ft)

Factors Of Safety Calculated By Spencer`s Method of Slices

172

ROCKY FLATS OLF - M&E SECTION D - WCS = 20 deg - W/HIGHGW - SLIDING BLOCK - STATIC
All surfaces evaluated. C:DEHSS.PLT By: STAN KLINE 10-23-04 10:50pm

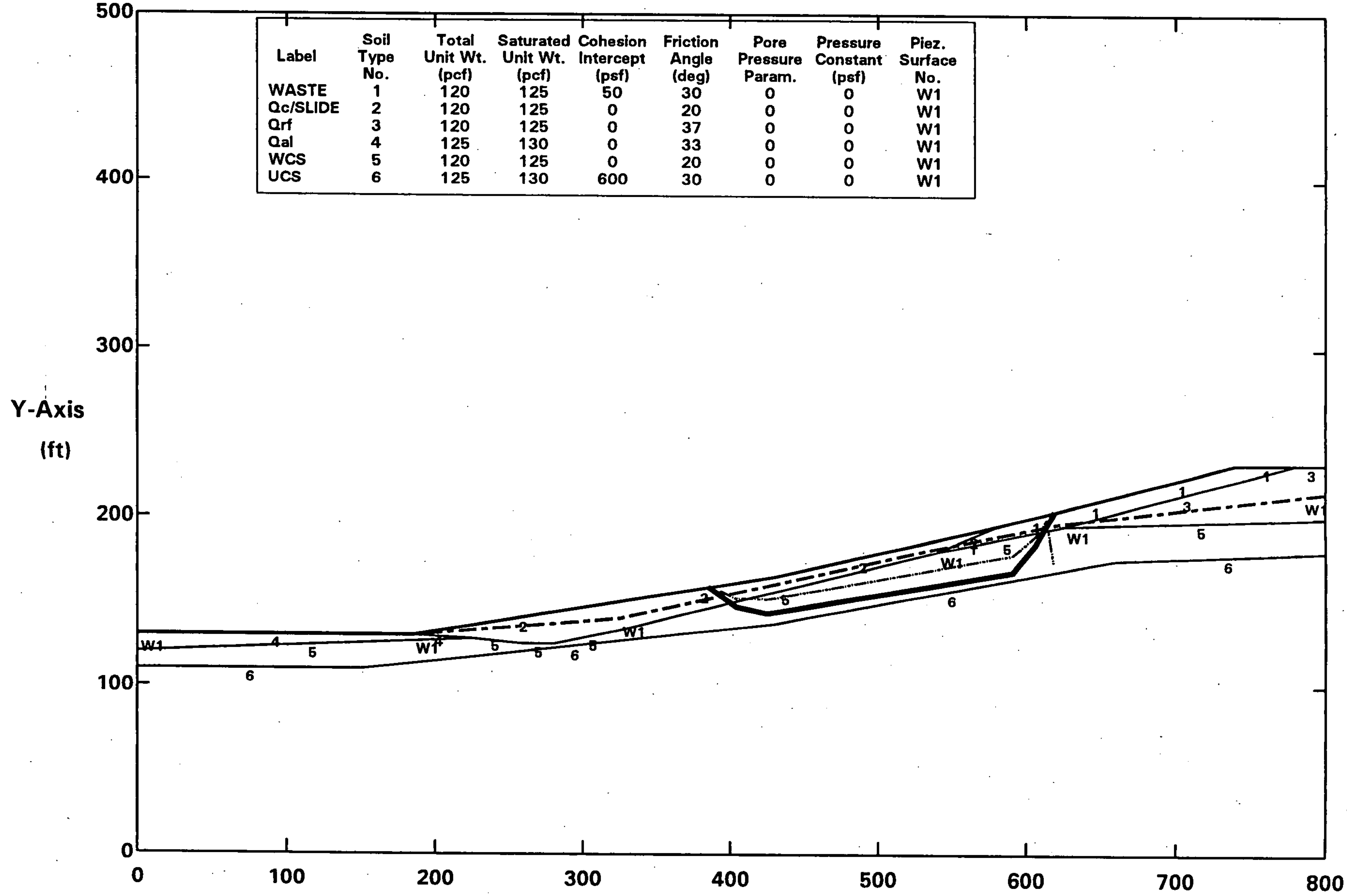


Factors Of Safety Calculated By The Modified Janbu Method

173

ROCKY FLATS OLF - M&E SECTION D - WCS=20 deg - W/HIGHGW - SLIDING BLOCK - STATIC
Surface #1-DEHSS.OUT. C:DEHSSSP.PLT By: STAN KLINE 10-23-04 11:23pm

Label	Soil Type No.	Total Unit Wt. (pcf)	Saturated Unit Wt. (pcf)	Cohesion Intercept (psf)	Friction Angle (deg)	Pore Pressure Param.	Pressure Constant (psf)	Piez. Surface No.
WASTE	1	120	125	50	30	0	0	W1
Qc/SLIDE	2	120	125	0	20	0	0	W1
Qrf	3	120	125	0	37	0	0	W1
Qal	4	125	130	0	33	0	0	W1
WCS	5	120	125	0	20	0	0	W1
UCS	6	125	130	600	30	0	0	W1



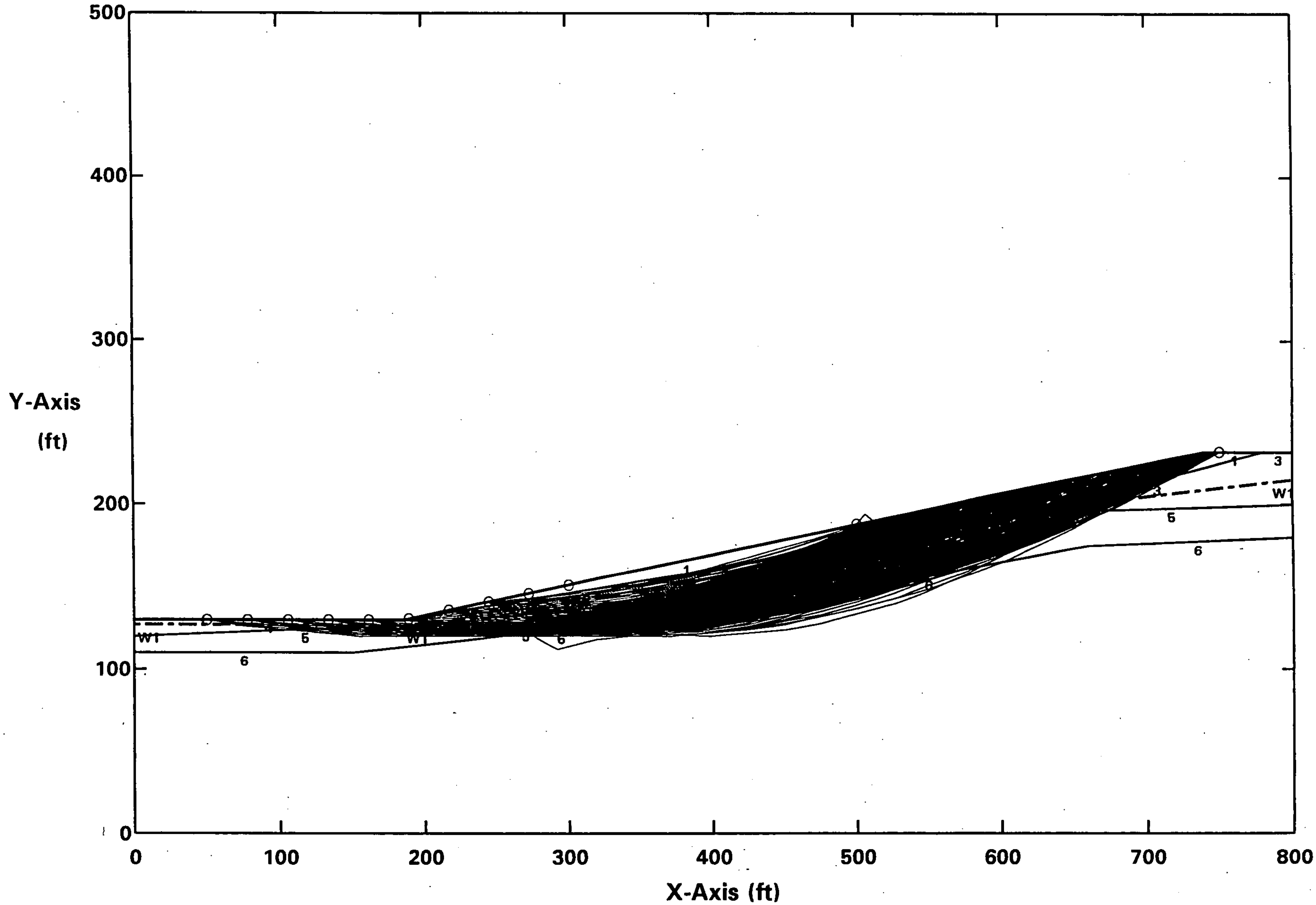
PCSTABL5M/SI FS=1.39 Theta=9.31 X-Axis (ft)
Factors Of Safety Calculated By Spencer`s Method of Slices

18% REGRADE CONDITION

174

175

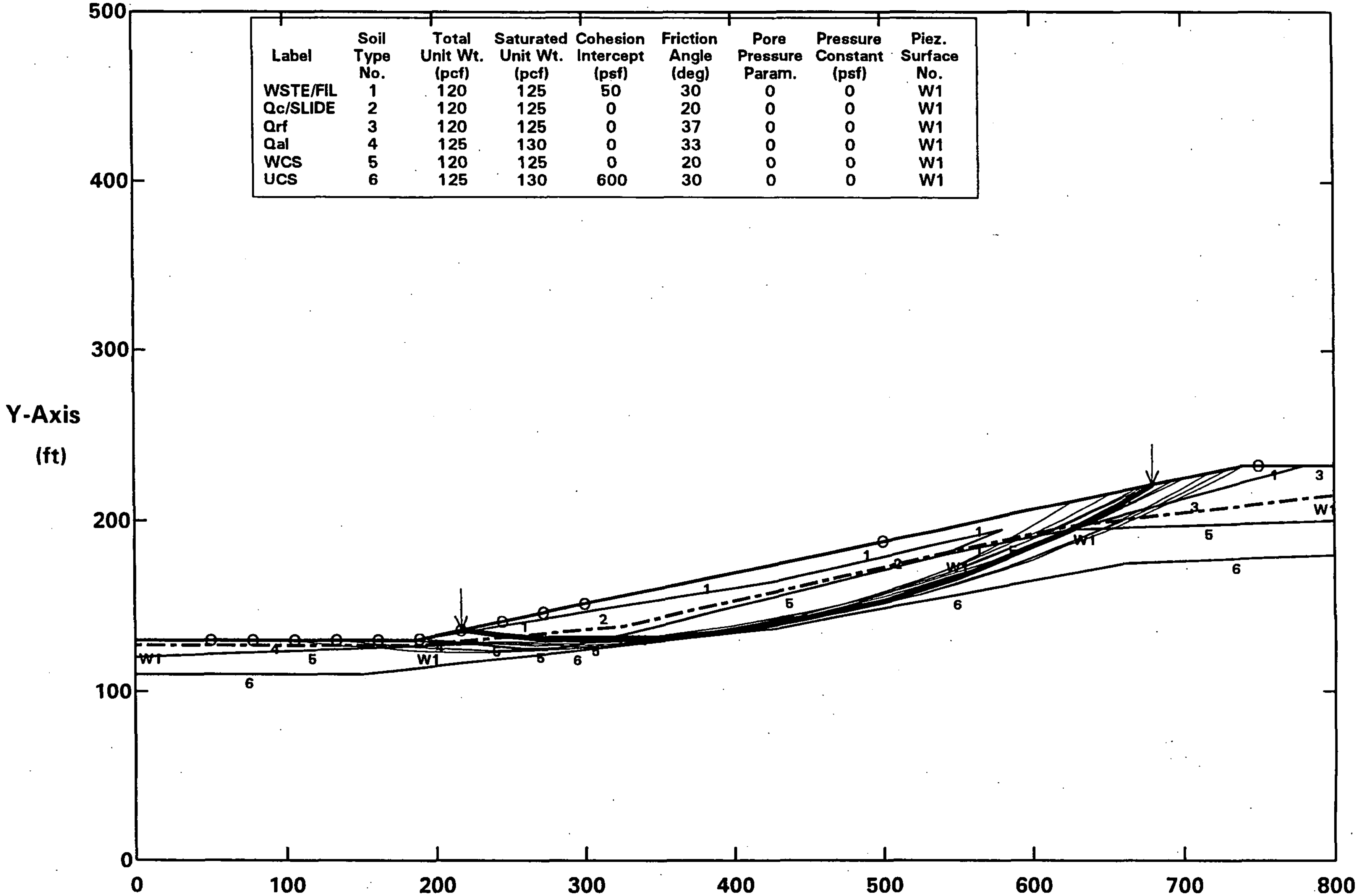
ROCKY FLATS OLF - M&E D 18% GRD - WCS = 20 deg - W/AVEGW - CIRCULAR - STATIC
All surfaces evaluated. C:DGACS.PLT By: STAN KLINE 10-24-04 2:17am



Factors Of Safety Calculated By The Modified Bishop Method

172

ROCKY FLATS OLF - M&E D 18% GRD - WCS = 20 deg - W/AVEGW - CIRCULAR - STATIC
Ten Most Critical. C:DGACS.PLT By: STAN KLINE 10-24-04 2:17am

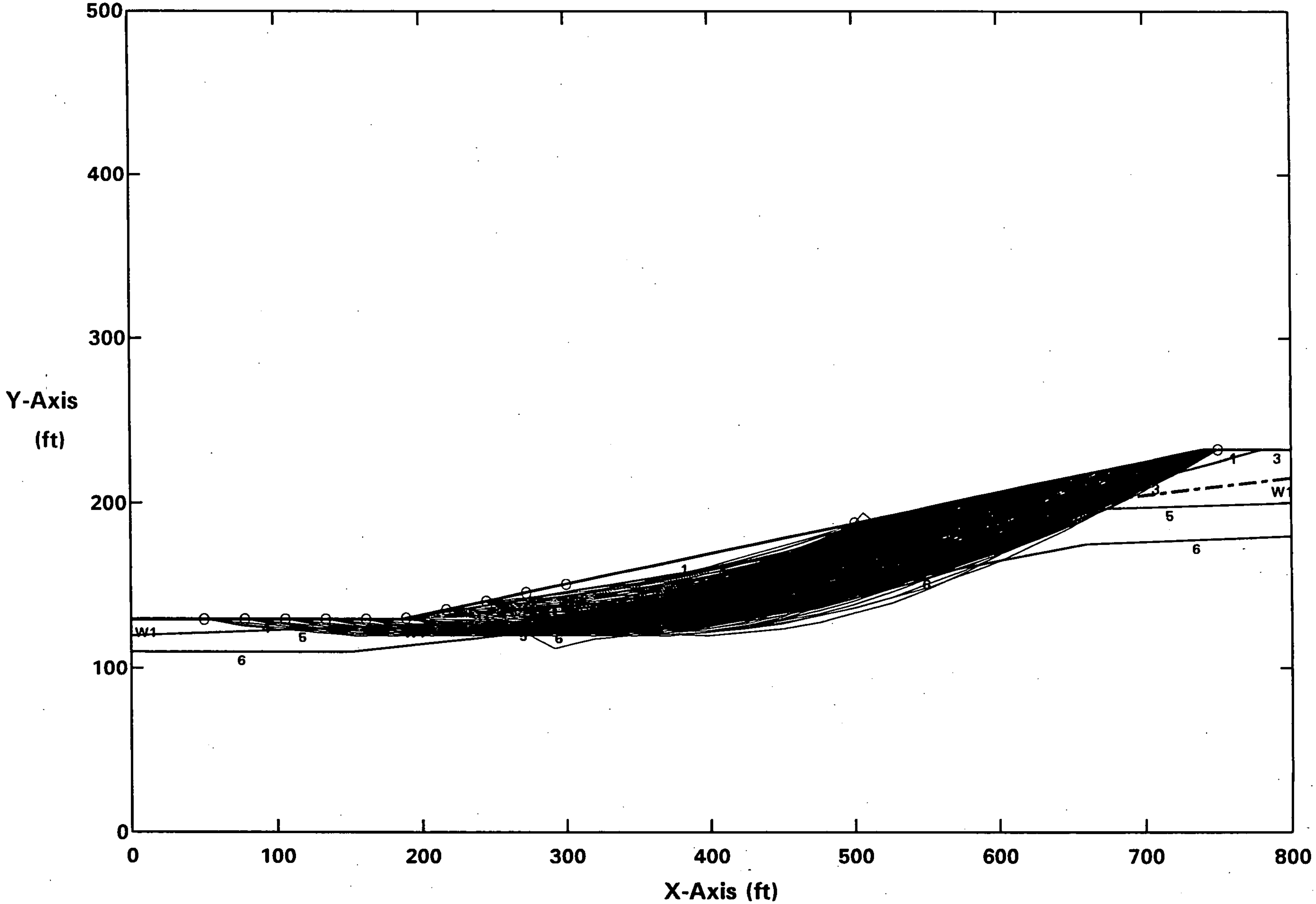


Label	Soil Type No.	Total Unit Wt. (pcf)	Saturated Unit Wt. (pcf)	Cohesion Intercept (psf)	Friction Angle (deg)	Pore Pressure Param.	Pressure Constant (psf)	Piez. Surface No.
WSTE/FIL	1	120	125	50	30	0	0	W1
Qc/SLIDE	2	120	125	0	20	0	0	W1
Qrf	3	120	125	0	37	0	0	W1
Qal	4	125	130	0	33	0	0	W1
WCS	5	120	125	0	20	0	0	W1
UCS	6	125	130	600	30	0	0	W1

PCSTABL5M/SI FSmin = 1.65 X-Axis (ft)
Factors Of Safety Calculated By The Modified Bishop Method

173

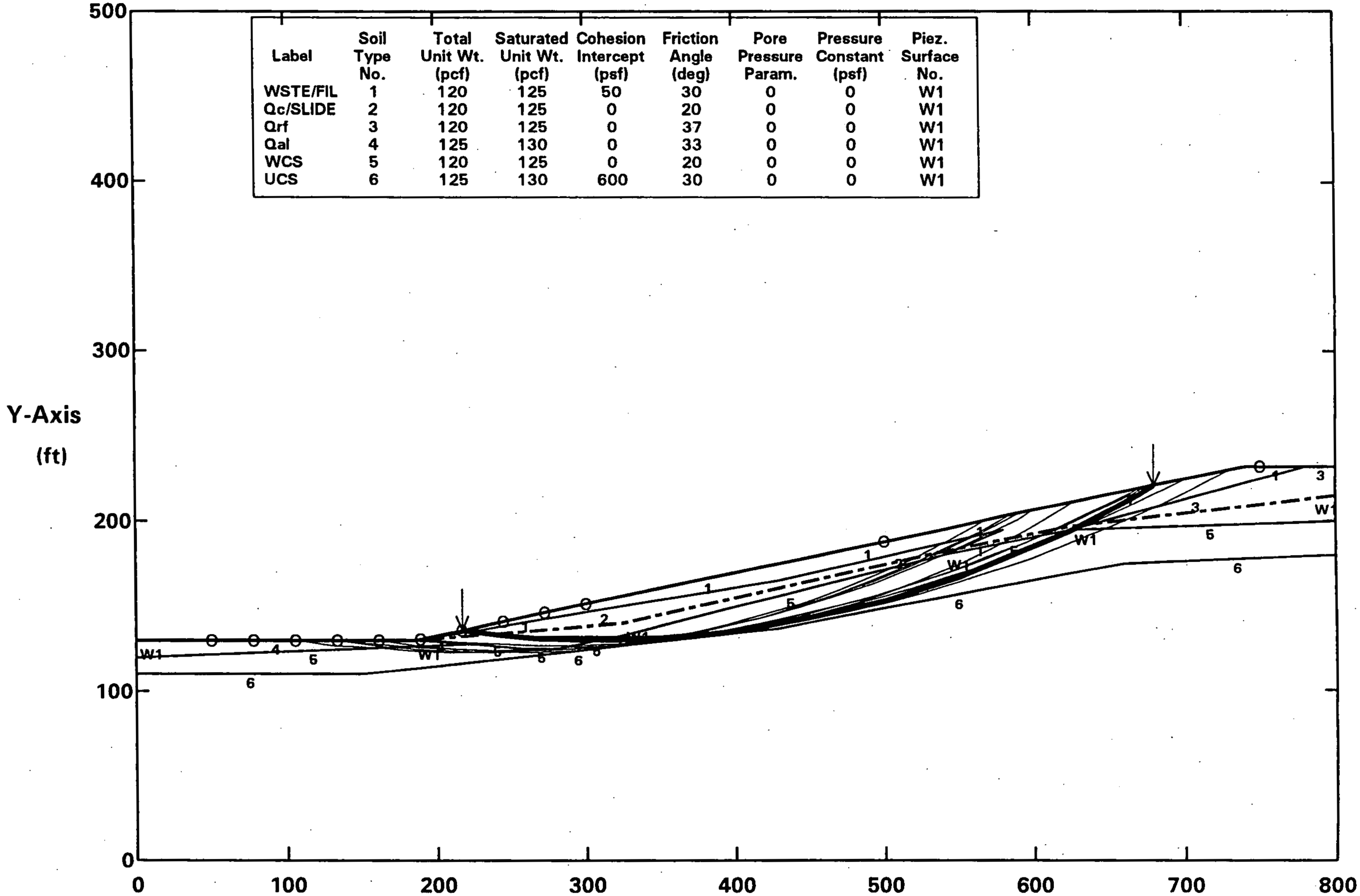
ROCKY FLATS OLF - M&E D 18% GRD - WCS = 20 deg - W/HIGHGW - CIRCULAR - STATIC
All surfaces evaluated. C:DGHCS.PLT By: STAN KLINE 10-24-04 1:17am



Factors Of Safety Calculated By The Modified Bishop Method

178

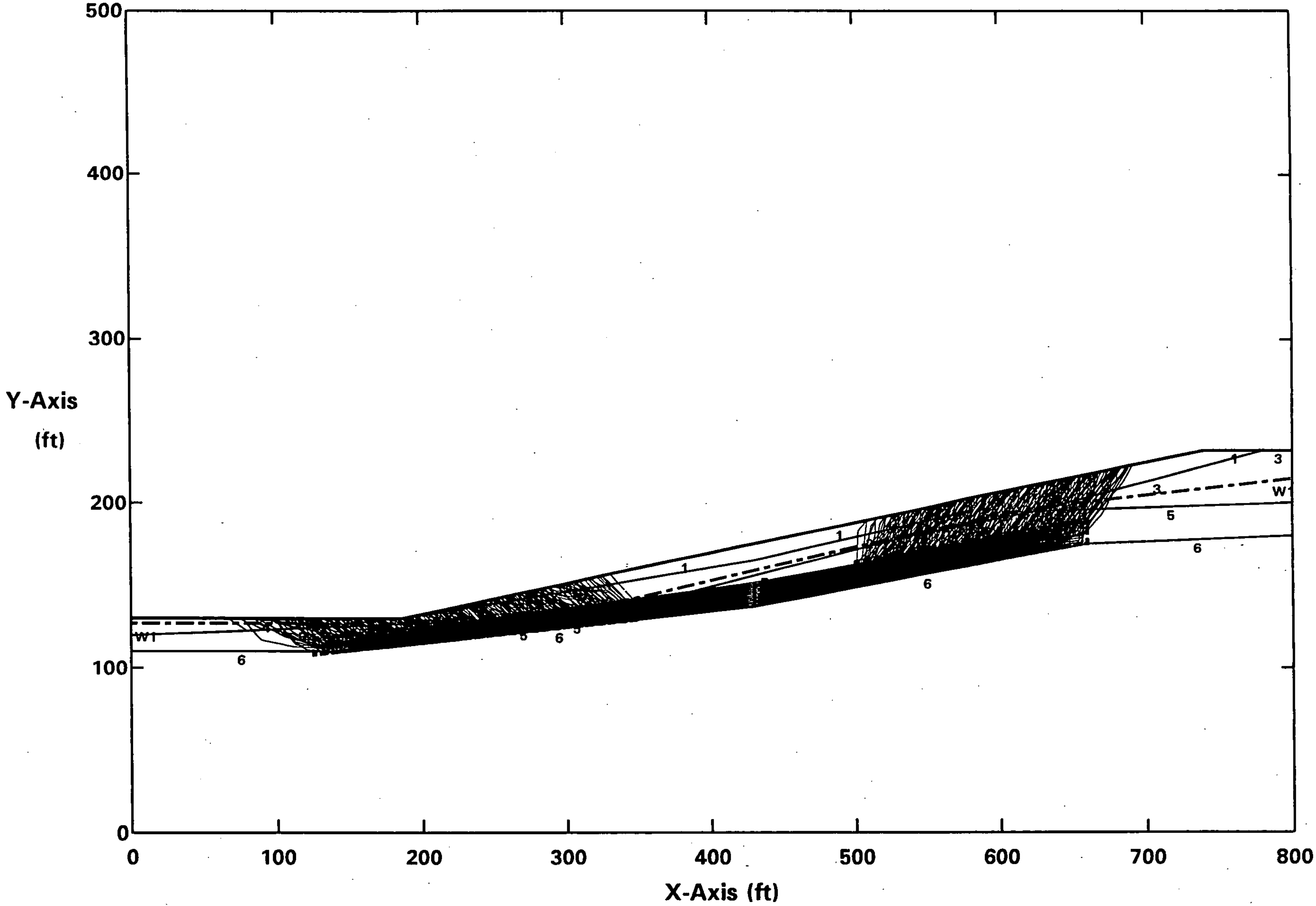
ROCKY FLATS OLF - M&E D 18% GRD - WCS=20 deg - W/HIGHGW - CIRCULAR - STATIC
Ten Most Critical. C:DGHCS.PLT By: STAN KLINE 10-24-04 1:17am



Label	Soil Type No.	Total Unit Wt. (pcf)	Saturated Unit Wt. (pcf)	Cohesion Intercept (psf)	Friction Angle (deg)	Pore Pressure Param.	Pressure Constant (psf)	Piez. Surface No.
WSTE/FIL	1	120	125	50	30	0	0	W1
Qc/SLIDE	2	120	125	0	20	0	0	W1
Qrf	3	120	125	0	37	0	0	W1
Qal	4	125	130	0	33	0	0	W1
WCS	5	120	125	0	20	0	0	W1
UCS	6	125	130	600	30	0	0	W1

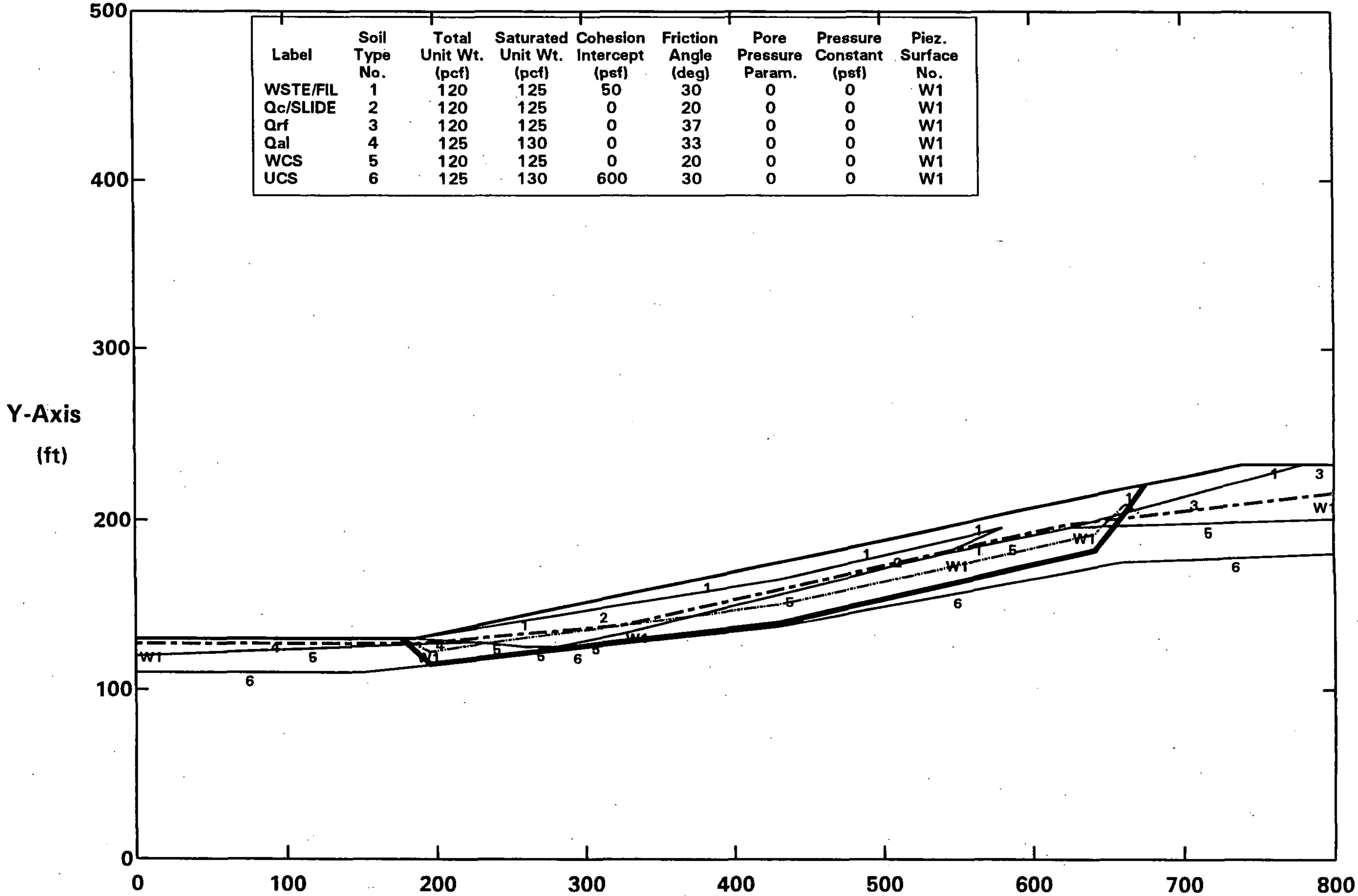
PCSTABL5M/SI FSmin=1.60 X-Axis (ft)
Factors Of Safety Calculated By The Modified Bishop Method

ROCKY FLATS OLF - M&E D 18% GRD - WCS = 20 deg - W/AVEGW - SLIDING BLOCK - STATIC
All surfaces evaluated. C:DGASS.PLT By: STAN KLINE 10-24-04 2:24am



Factors Of Safety Calculated By The Modified Janbu Method

ROCKY FLATS OLF - M&E D 18% GRD - WCS=20 deg - W/AVEGW - SLIDING BLOCK - STATIC
Surface #1-DGASS.OUT. C:DGASSSP.PLT By: STAN KLINE 10-24-04 2:26am

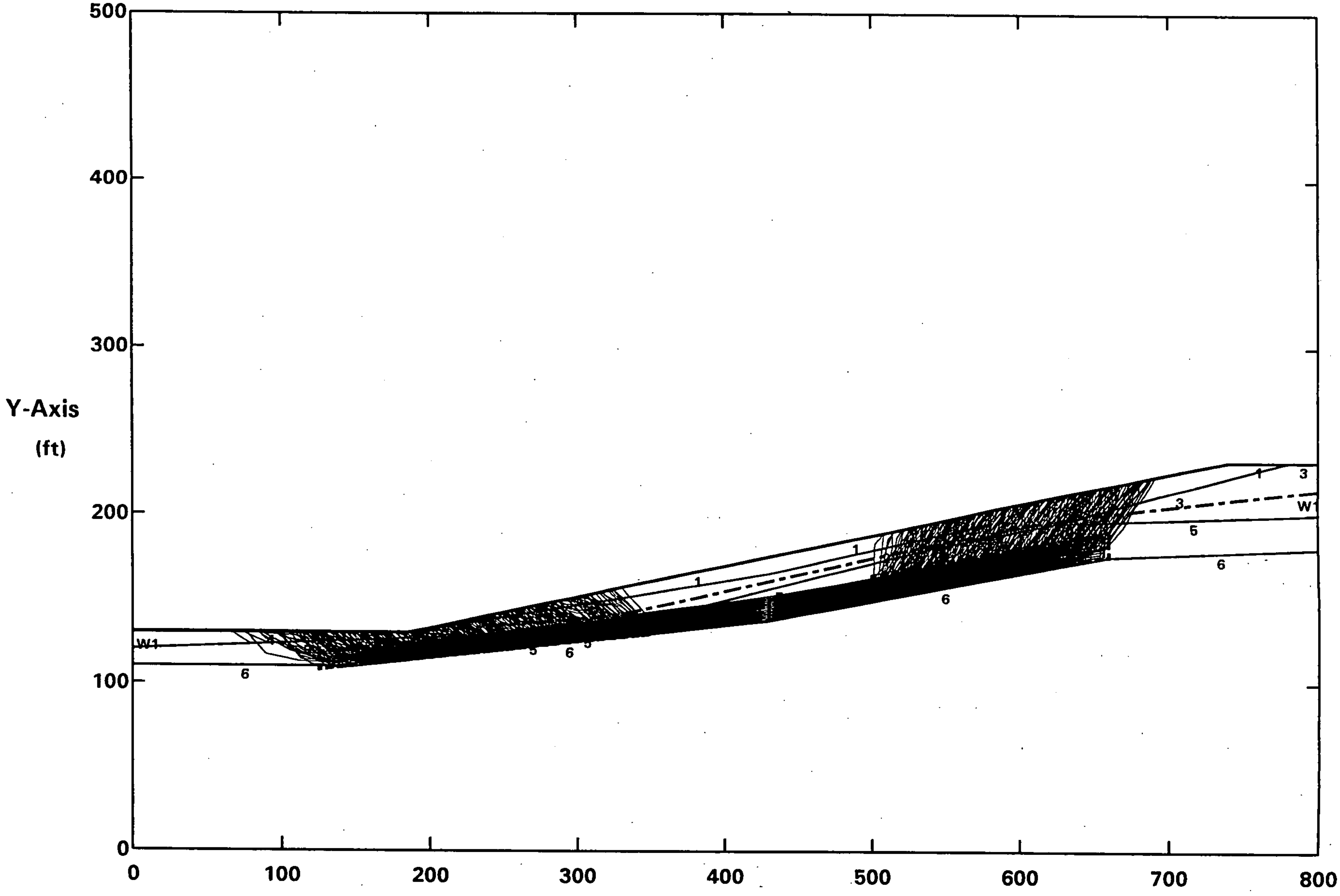


Label	Soil Type No.	Total Unit Wt. (pcf)	Saturated Unit Wt. (pcf)	Cohesion Intercept (psf)	Friction Angle (deg)	Pore Pressure Param.	Pressure Constant (psf)	Piez. Surface No.
WSTE/FIL	1	120	125	50	30	0	0	W1
Qc/SLIDE	2	120	125	0	20	0	0	W1
Qrf	3	120	125	0	37	0	0	W1
Qal	4	125	130	0	33	0	0	W1
WCS	5	120	125	0	20	0	0	W1
UCS	6	125	130	600	30	0	0	W1

PCSTABL5M/SI FS=1.61 Theta=9.29 X-Axis (ft)
Factors Of Safety Calculated By Spencer`s Method of Slices

181

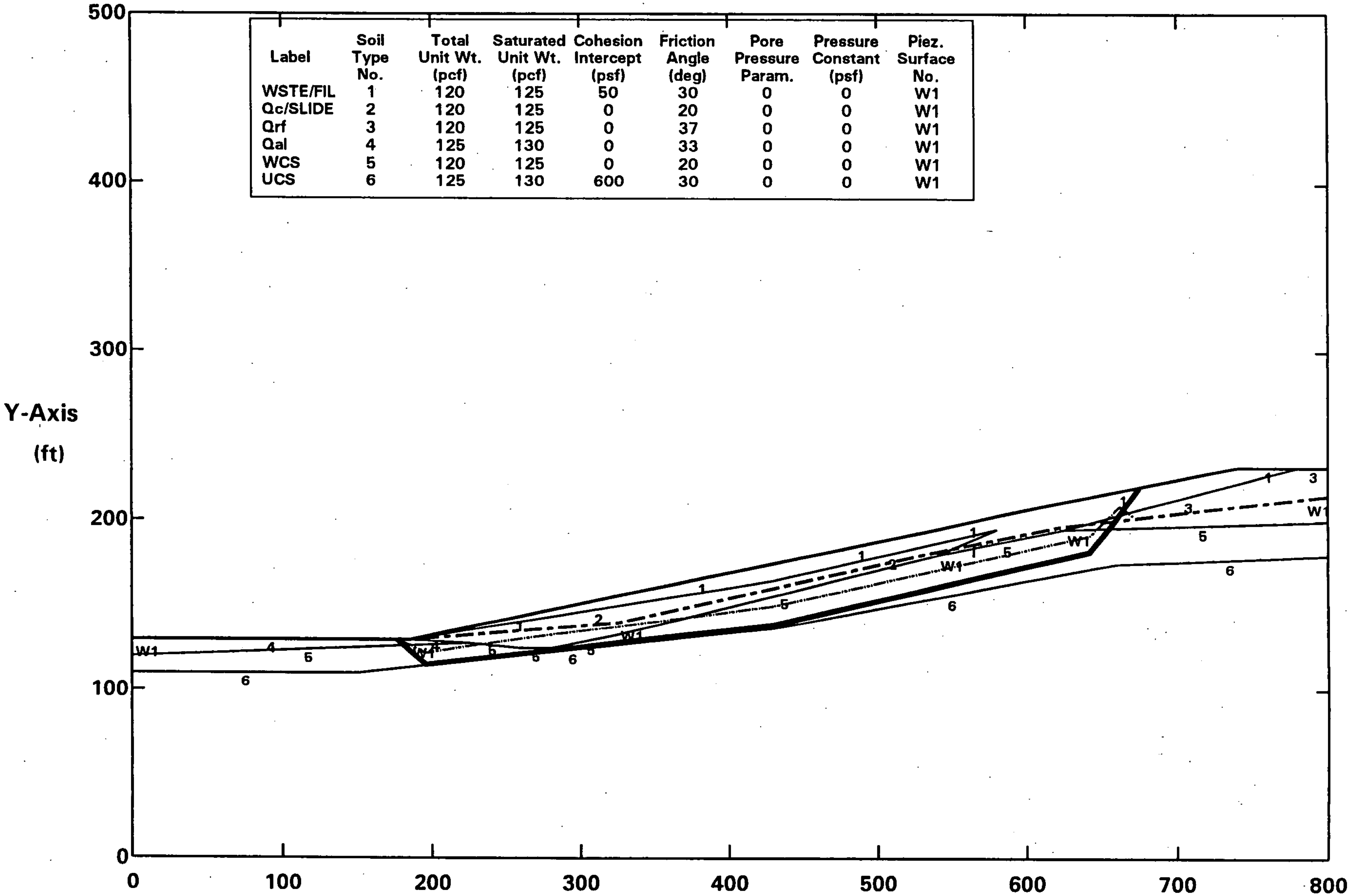
ROCKY FLATS OLF - M&E D 18% GRD - WCS=20 deg - W/HIGHGW - SLIDING BLOCK - STATIC
All surfaces evaluated. C:DGHSS.PLT By: STAN KLINE 10-23-04 11:19pm



Factors Of Safety Calculated By The Modified Janbu Method

ROCKY FLATS OLF - M&E D 18% GRD - WCS=20 deg - W/HIGHGW - SLIDING BLOCK - STATIC
Surface #1-DGHSS.OUT. C:DGHSSSP.PLT By: STAN KLINE 10-23-04 11:21pm

Label	Soil Type No.	Total Unit Wt. (pcf)	Saturated Unit Wt. (pcf)	Cohesion Intercept (psf)	Friction Angle (deg)	Pore Pressure Param.	Pressure Constant (psf)	Piez. Surface No.
WSTE/FIL	1	120	125	50	30	0	0	W1
Qc/SLIDE	2	120	125	0	20	0	0	W1
Qrf	3	120	125	0	37	0	0	W1
Qal	4	125	130	0	33	0	0	W1
WCS	5	120	125	0	20	0	0	W1
UCS	6	125	130	600	30	0	0	W1

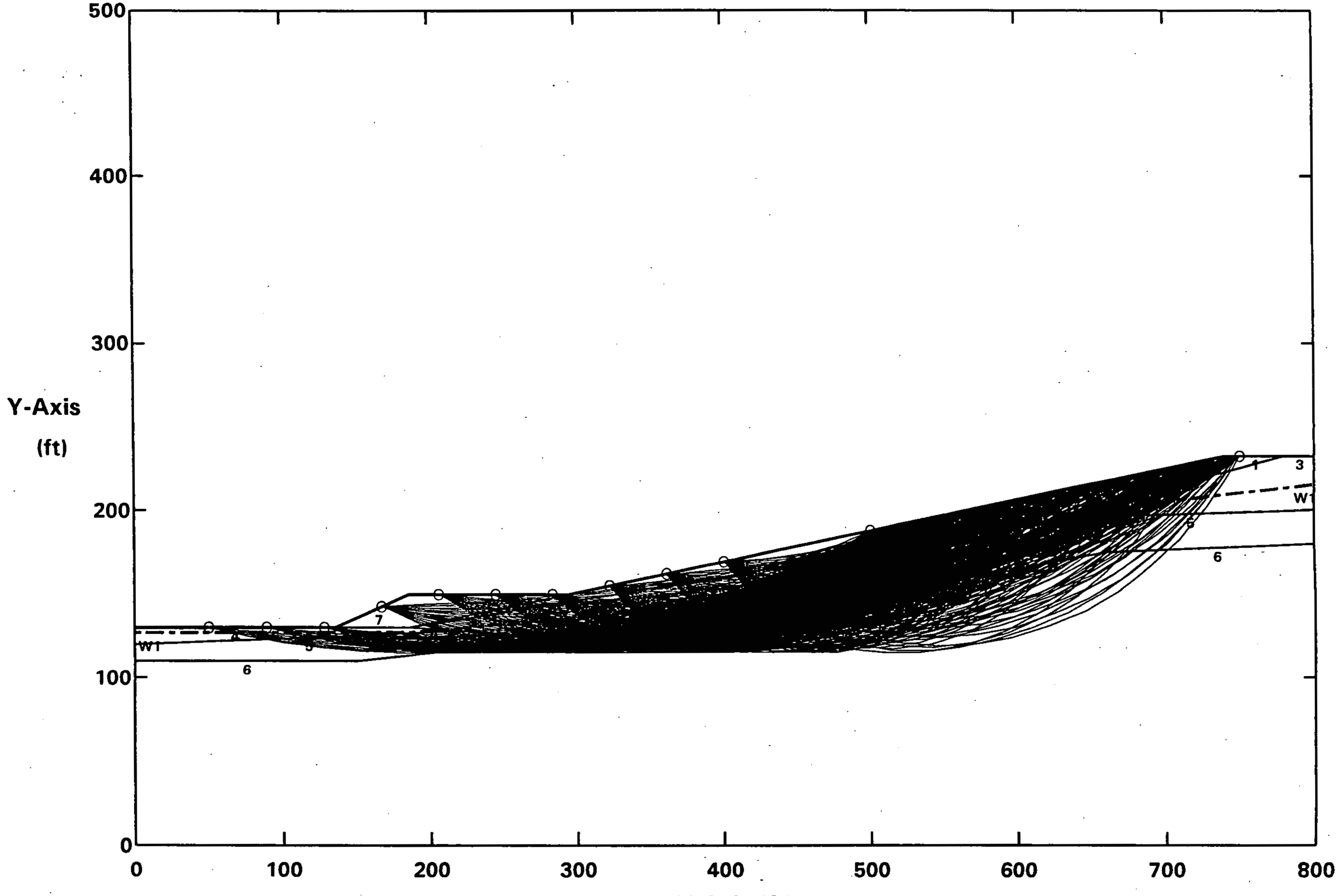


PCSTABL5M/SI FS=1.55 Theta=9.36 X-Axis (ft)
Factors Of Safety Calculated By Spencer`s Method of Slices

18% REGRADE WITH BUTTRESS CONDITION

184

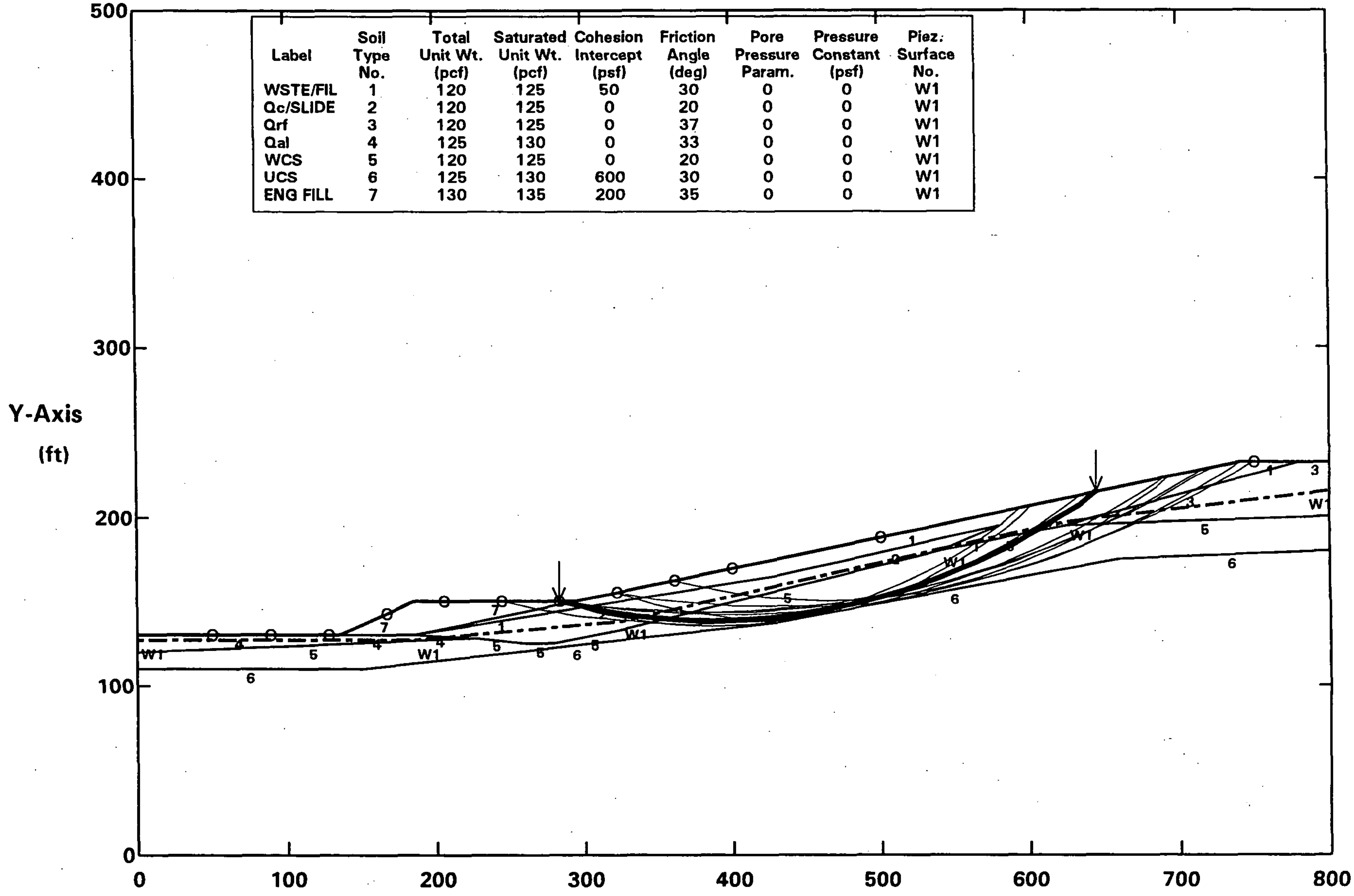
ROCKY FLATS OLF - M&E D 18%W/BM - WCS = 20 deg - W/AVEGW - CIRCULAR - STATIC
All surfaces evaluated. C:DBACS.PLT By: STAN KLINE 10-24-04 2:14am



Factors Of Safety Calculated By The Modified Bishop Method

181

ROCKY FLATS OLF - M&E D 18%W/BM - WCS=20 deg - W/AVEGW - CIRCULAR - STATIC
Ten Most Critical. C:DBACS.PLT By: STAN KLINE 10-24-04 2:14am

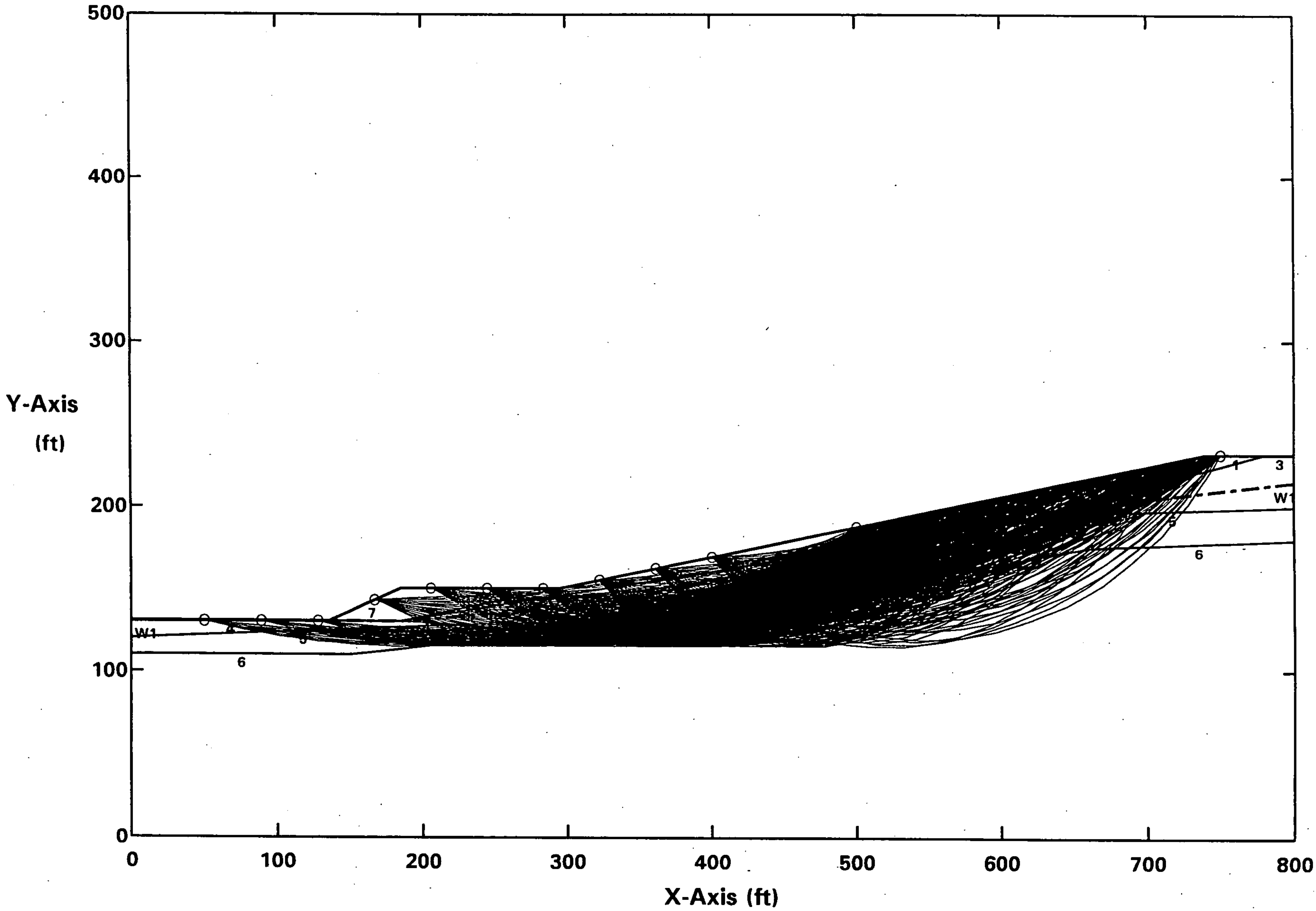


Label	Soil Type No.	Total Unit Wt. (pcf)	Saturated Unit Wt. (pcf)	Cohesion Intercept (psf)	Friction Angle (deg)	Pore Pressure Param.	Pressure Constant (psf)	Piez. Surface No.
WSTE/FIL	1	120	125	50	30	0	0	W1
Qc/SLIDE	2	120	125	0	20	0	0	W1
Qrf	3	120	125	0	37	0	0	W1
Qal	4	125	130	0	33	0	0	W1
WCS	5	120	125	0	20	0	0	W1
UCS	6	125	130	600	30	0	0	W1
ENG FILL	7	130	135	200	35	0	0	W1

PCSTABL5M/SI FSmin=1.70 X-Axis (ft)
Factors Of Safety Calculated By The Modified Bishop Method

186

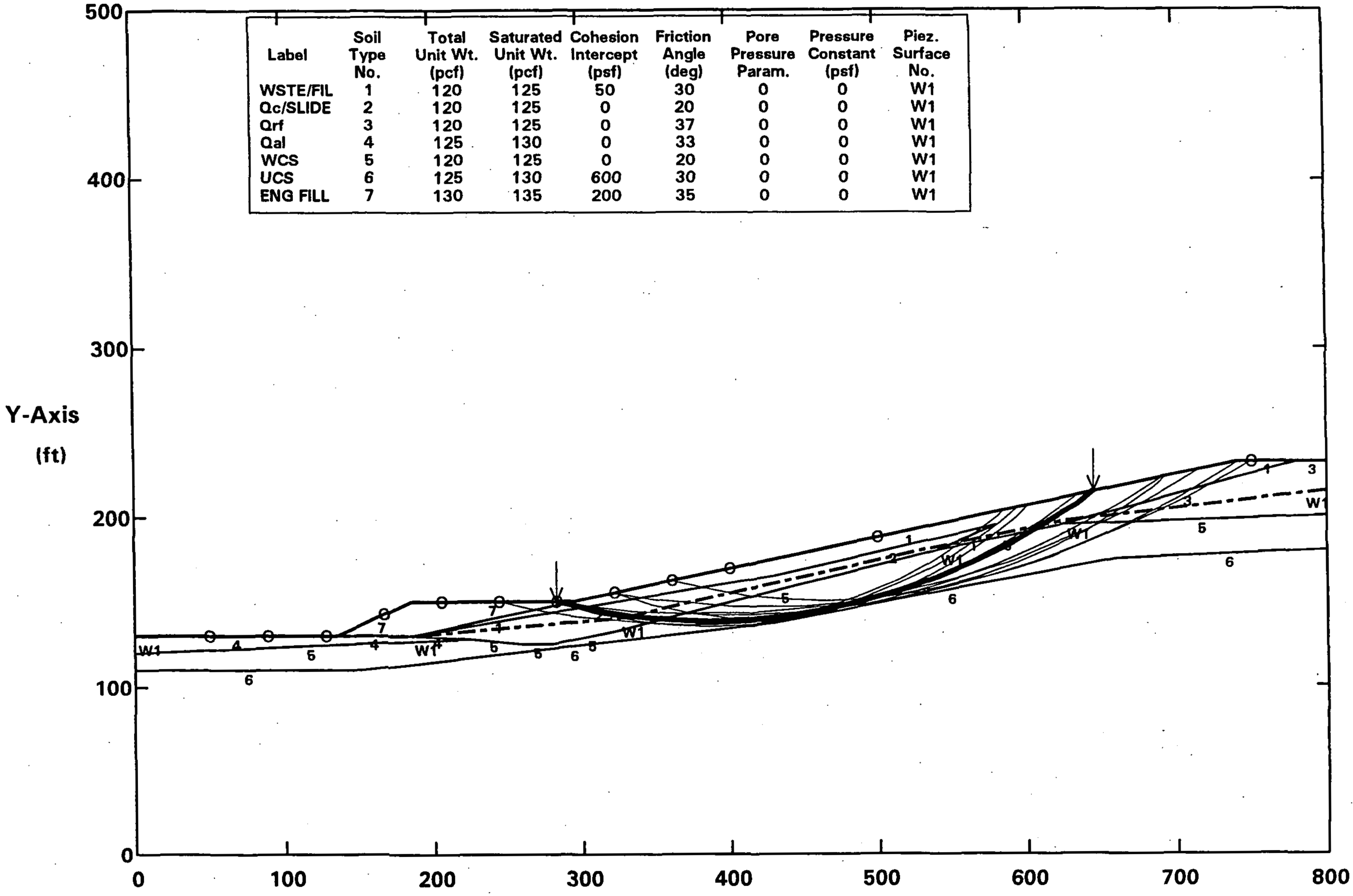
ROCKY FLATS OLF - M&E D 18%W/BM - WCS = 20 deg - W/HIGHGW - CIRCULAR - STATIC
All surfaces evaluated. C:DBHCS.PLT By: STAN KLINE 10-24-04 1:48am



Factors Of Safety Calculated By The Modified Bishop Method

187

ROCKY FLATS OLF - M&E D 18%W/BM - WCS=20 deg - W/HIGHGW - CIRCULAR - STATIC
Ten Most Critical. C:DBHCS.PLT By: STAN KLINE 10-24-04 1:48am

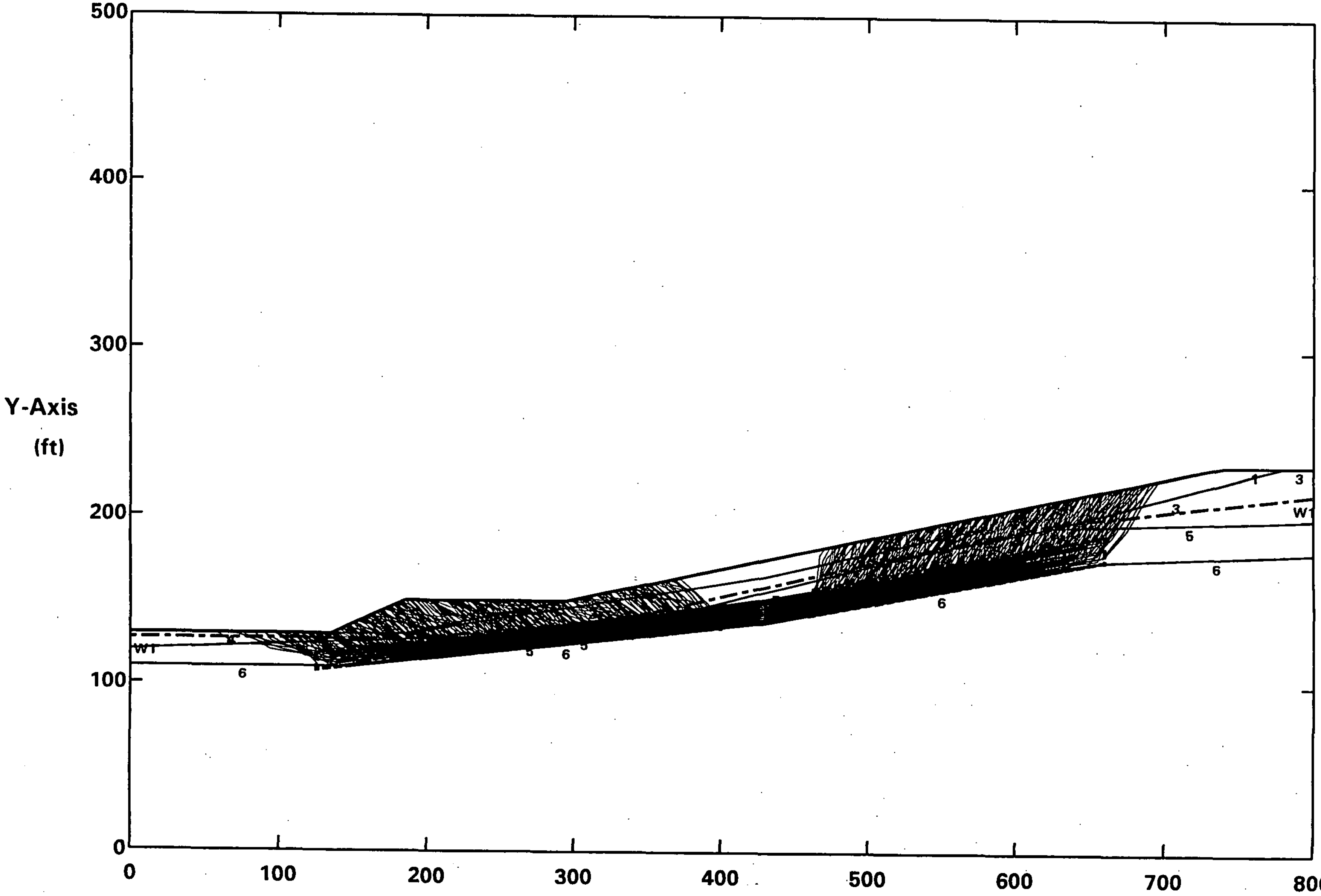


Label	Soil Type No.	Total Unit Wt. (pcf)	Saturated Unit Wt. (pcf)	Cohesion Intercept (psf)	Friction Angle (deg)	Pore Pressure Param.	Pressure Constant (psf)	Piez. Surface No.
WSTE/FIL	1	120	125	50	30	0	0	W1
Qc/SLIDE	2	120	125	0	20	0	0	W1
Qrf	3	120	125	0	37	0	0	W1
Qal	4	125	130	0	33	0	0	W1
WCS	5	120	125	0	20	0	0	W1
UCS	6	125	130	600	30	0	0	W1
ENG FILL	7	130	135	200	35	0	0	W1

PCSTABL5M/SI FSmin=1.66 X-Axis (ft)
Factors Of Safety Calculated By The Modified Bishop Method

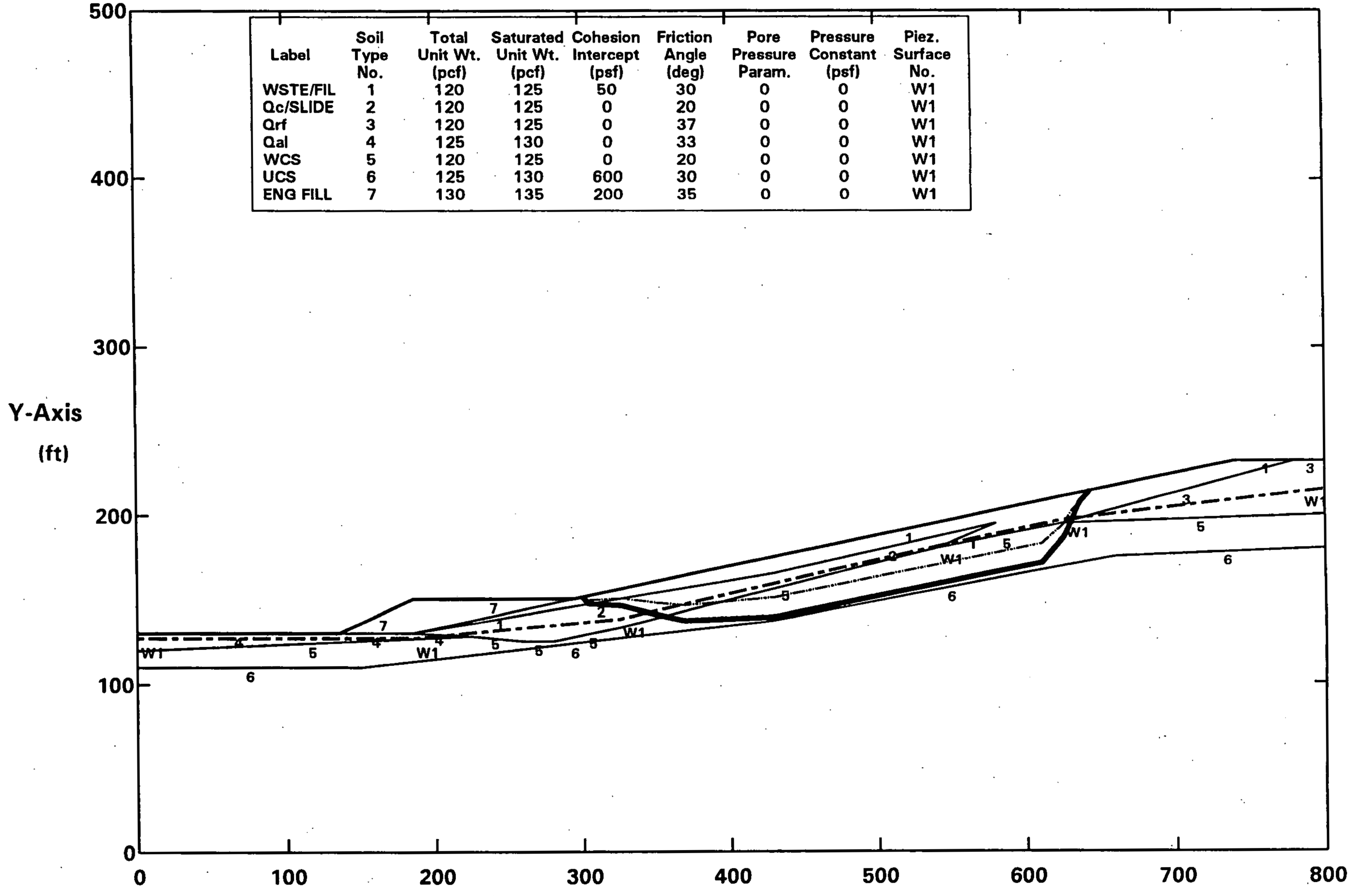
188

ROCKY FLATS OLF - M&E D 18%W/BM - WCS=20 deg - W/AVEGW - SLIDING BLOCK - STATIC
All surfaces evaluated. C:DBASS.PLT By: STAN KLINE 10-24-04 2:28am



Factors Of Safety Calculated By The Modified Janbu Method

ROCKY FLATS OLF - M&E D 18%W/BM - WCS=20 deg - W/AVEGW - SLIDING BLOCK - STATIC
Surface #1-DBASS.OUT. C:DBASSSP.PLT By: STAN KLINE 10-24-04 2:30am

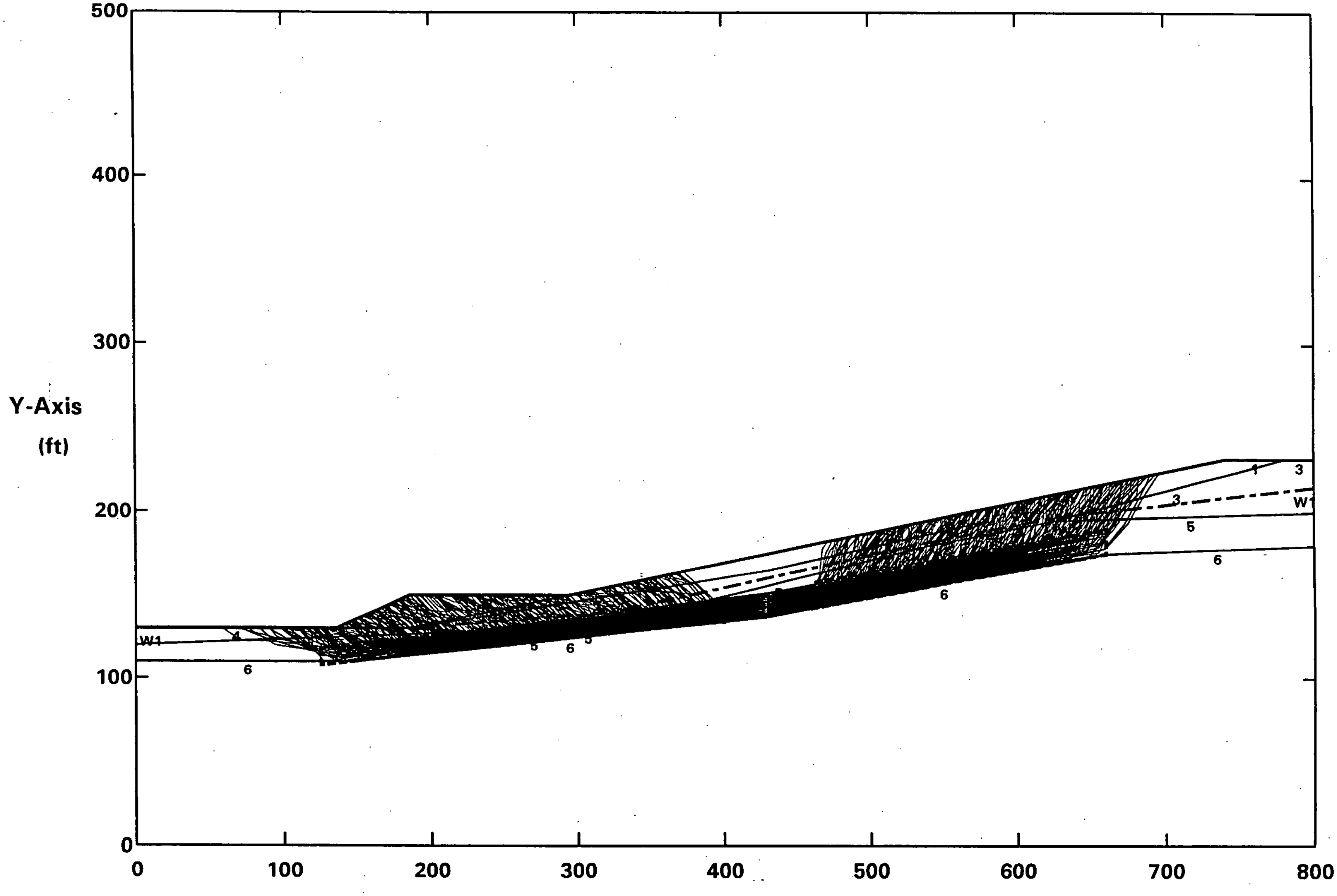


Label	Soil Type No.	Total Unit Wt. (pcf)	Saturated Unit Wt. (pcf)	Cohesion Intercept (psf)	Friction Angle (deg)	Pore Pressure Param.	Pressure Constant (psf)	Piez. Surface No.
WSTE/FIL	1	120	125	50	30	0	0	W1
Qc/SLIDE	2	120	125	0	20	0	0	W1
Qrf	3	120	125	0	37	0	0	W1
Qal	4	125	130	0	33	0	0	W1
WCS	5	120	125	0	20	0	0	W1
UCS	6	125	130	600	30	0	0	W1
ENG FILL	7	130	135	200	35	0	0	W1

PCSTABL5M/SI FS=1.71 Theta=8.77 X-Axis (ft)
Factors Of Safety Calculated By Spencer`s Method of Slices

32

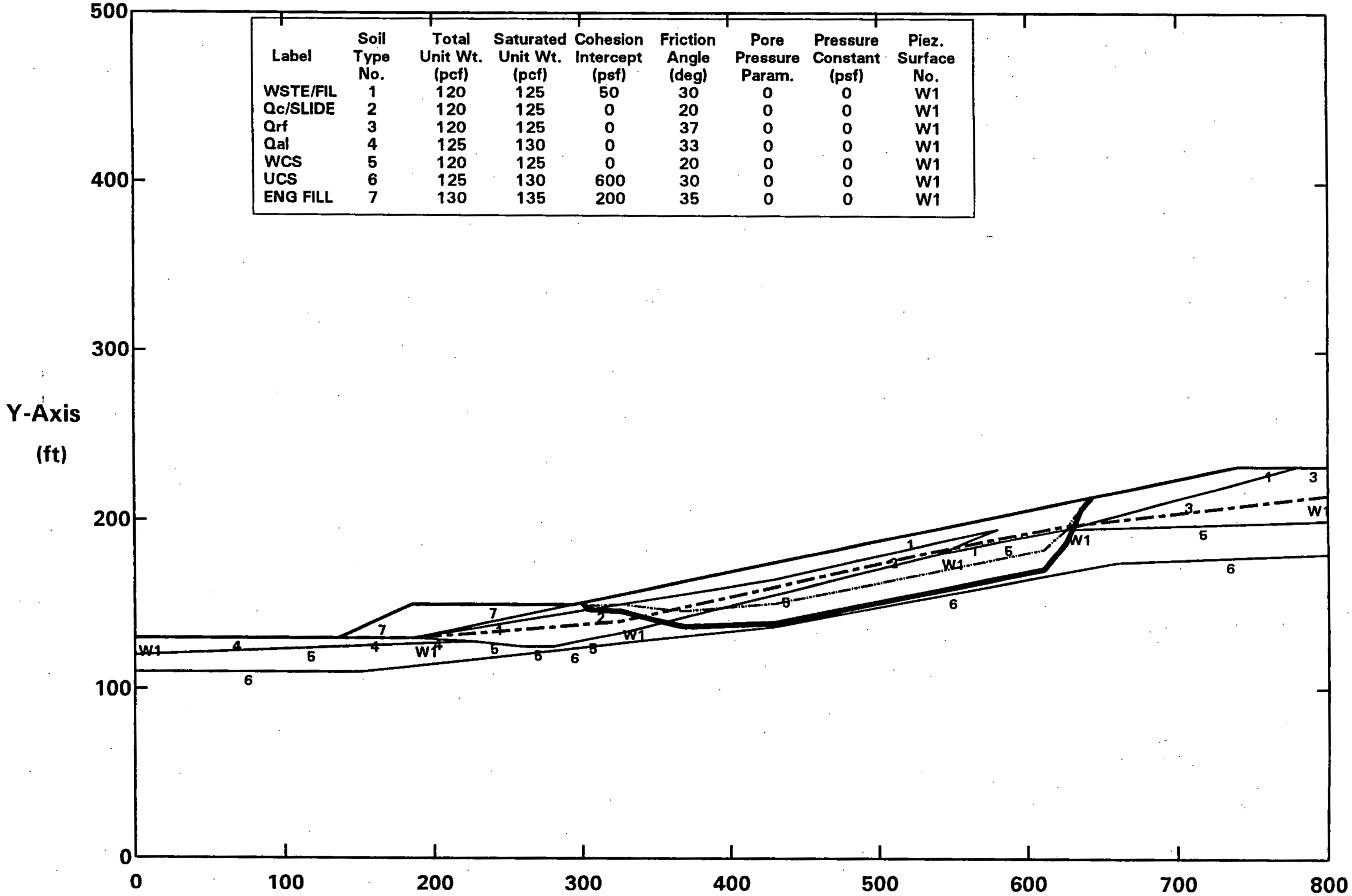
ROCKY FLATS OLF - M&E D 18%W/BM - WCS=20 deg - W/HIGHGW - SLIDING BLOCK - STATIC
All surfaces evaluated. C:DBHSS.PLT By: STAN KLINE 10-23-04 11:58pm



Factors Of Safety Calculated By The Modified Janbu Method

ROCKY FLATS OLF - M&E D 18%W/BM - WCS = 20 deg - W/HIGHGW - SLIDING BLOCK - STATIC
Surface #1-DBHSS.OUT. C:DBHSSSP.PLT By: STAN KLINE 10-24-04 12:02am

Label	Soil Type No.	Total Unit Wt. (pcf)	Saturated Unit Wt. (pcf)	Cohesion Intercept (psf)	Friction Angle (deg)	Pore Pressure Param.	Pressure Constant (psf)	Piez. Surface No.
WSTE/FIL	1	120	125	50	30	0	0	W1
Qc/SLIDE	2	120	125	0	20	0	0	W1
Qrf	3	120	125	0	37	0	0	W1
Qal	4	125	130	0	33	0	0	W1
WCS	5	120	125	0	20	0	0	W1
UCS	6	125	130	600	30	0	0	W1
ENG FILL	7	130	135	200	35	0	0	W1

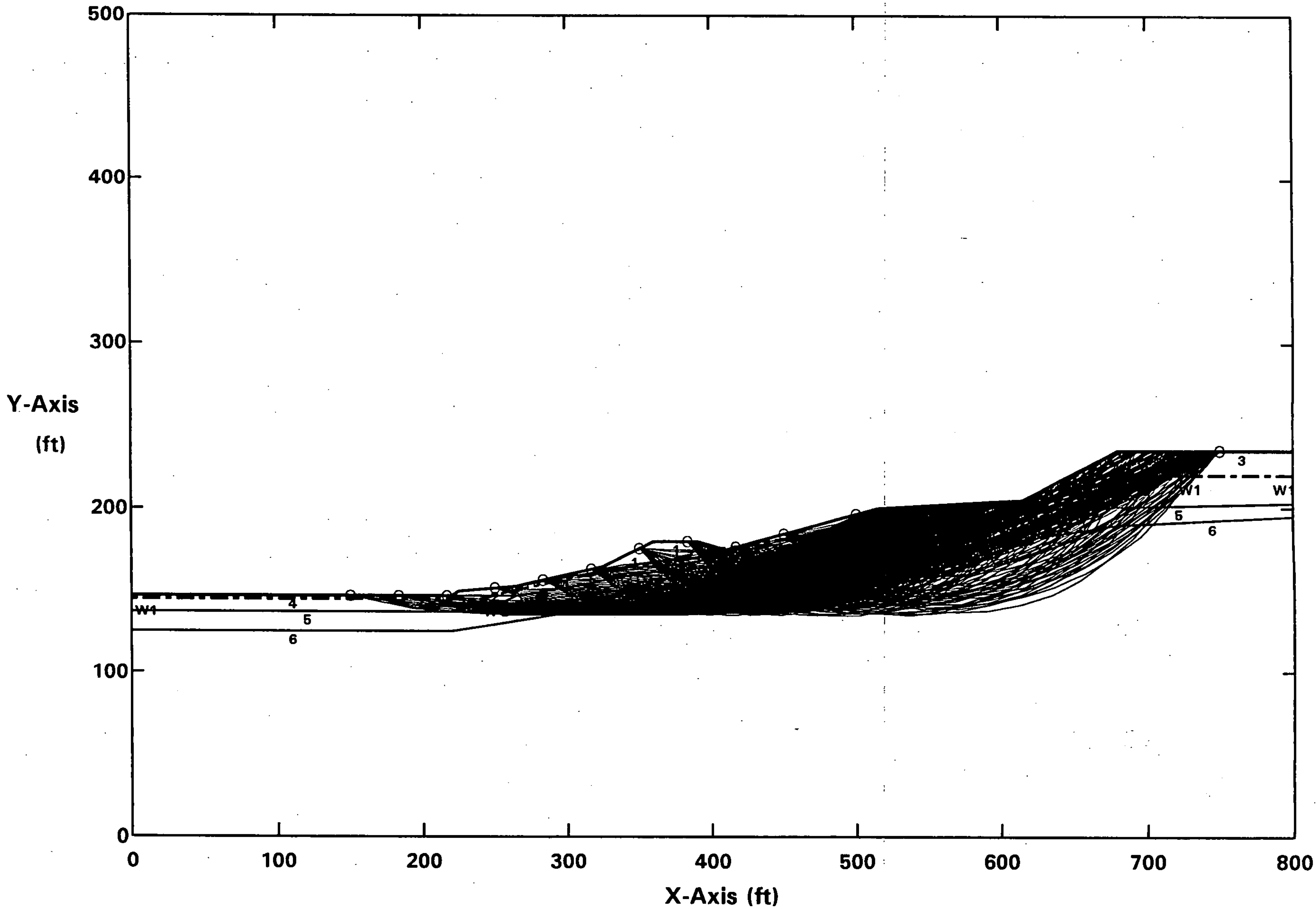


PCSTABL5M/SI FS = 1.67 Theta = 8.75 X-Axis (ft)
Factors Of Safety Calculated By Spencer`s Method of Slices

M&E SECTION B-B' – PSEUDOSTATIC

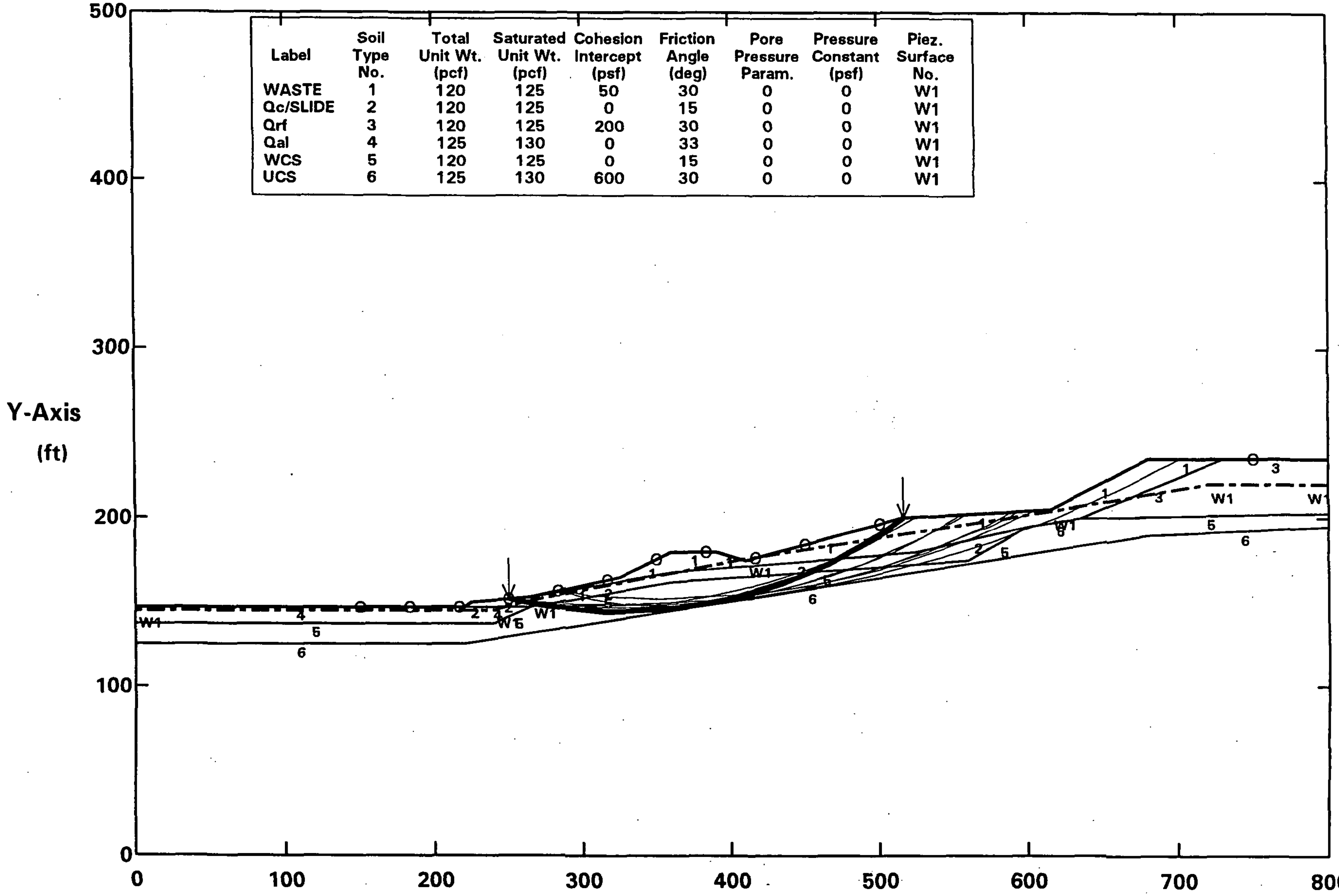
192

ROCKY FLATS OLF - M&E SECTION B - WCS = 15 deg - W/AVEGW - CIRCULAR - 0.06g
All surfaces evaluated. C:BEAC06.PLT By: STAN KLINE 10-24-04 3:46am



Factors Of Safety Calculated By The Modified Bishop Method

ROCKY FLATS OLF - M&E SECTION B - WCS = 15 deg - W/AVEGW - CIRCULAR - 0.06g
Ten Most Critical. C:BEAC06.PLT By: STAN KLINE 10-24-04 3:46am

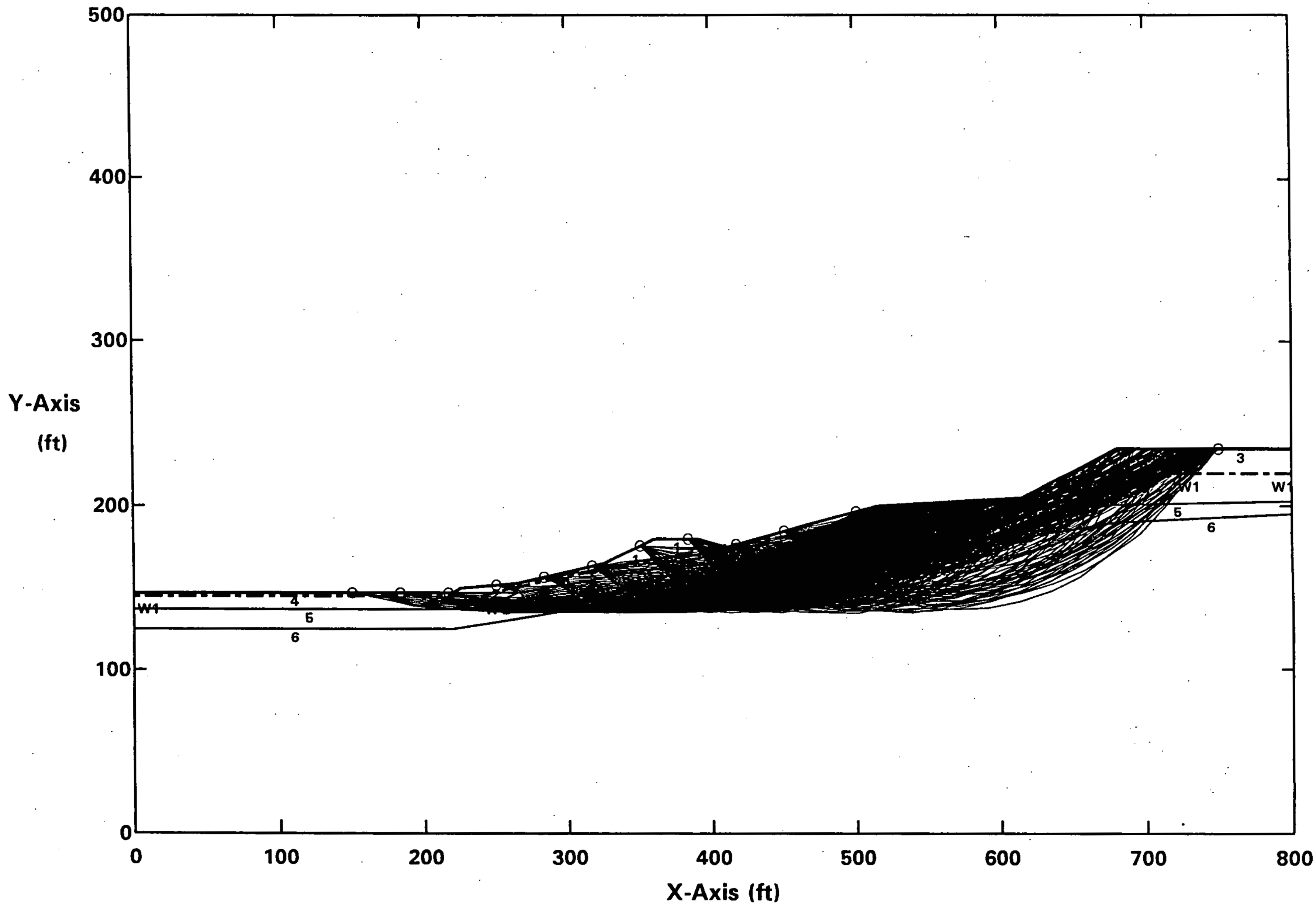


Label	Soil Type No.	Total Unit Wt. (pcf)	Saturated Unit Wt. (pcf)	Cohesion Intercept (psf)	Friction Angle (deg)	Pore Pressure Param.	Pressure Constant (psf)	Piez. Surface No.
WASTE	1	120	125	50	30	0	0	W1
Qc/SLIDE	2	120	125	0	15	0	0	W1
Qrf	3	120	125	200	30	0	0	W1
Qal	4	125	130	0	33	0	0	W1
WCS	5	120	125	0	15	0	0	W1
UCS	6	125	130	600	30	0	0	W1

PCSTABL5M/SI FSmin = 0.84 X-Axis (ft)
Factors Of Safety Calculated By The Modified Bishop Method

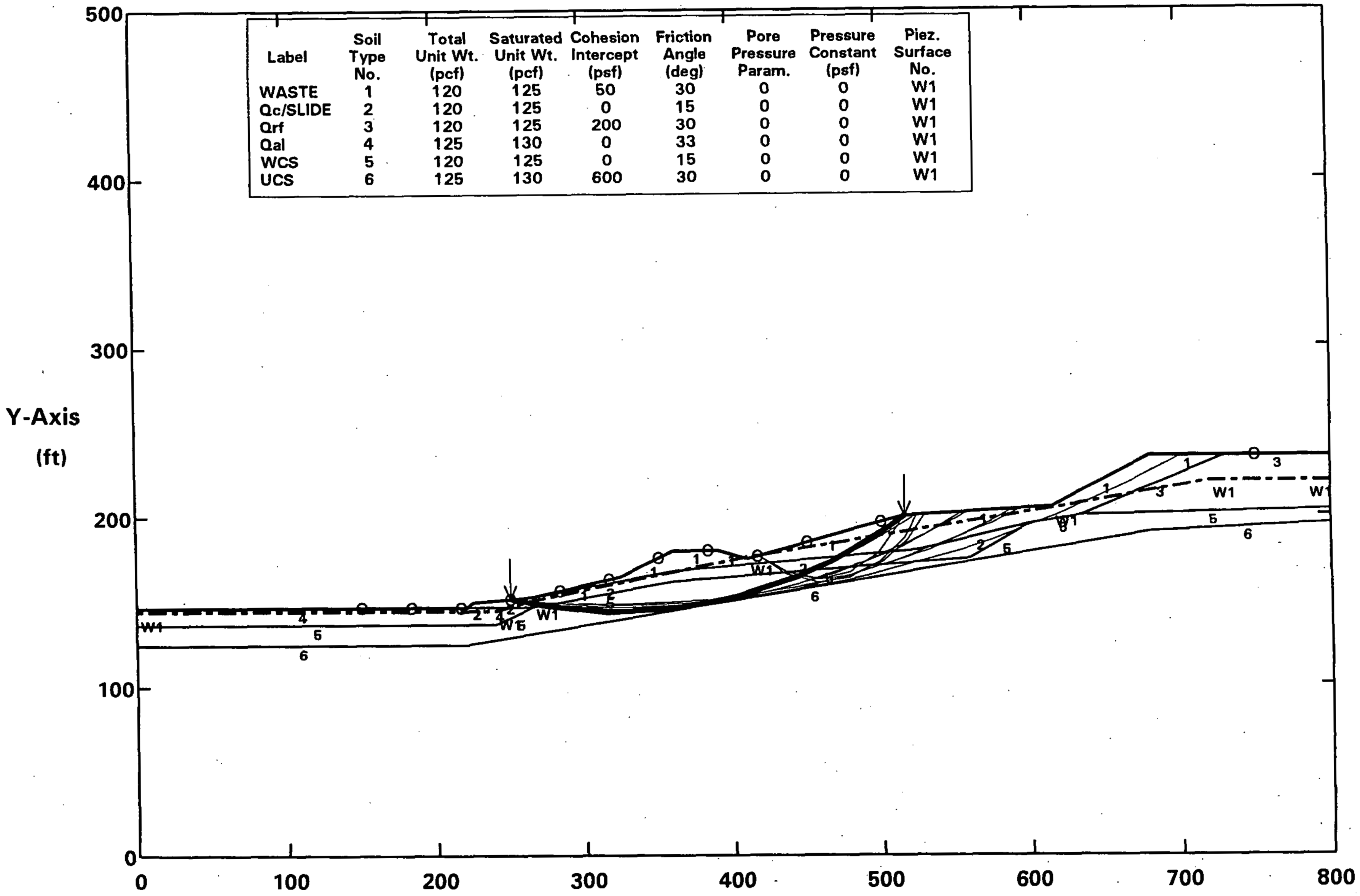
191

ROCKY FLATS OLF - M&E SECTION B - WCS = 15 deg - W/AVEGW - CIRCULAR - 0.02g
All surfaces evaluated. C:BEAC02.PLT By: STAN KLINE 10-24-04 3:45am



Factors Of Safety Calculated By The Modified Bishop Method

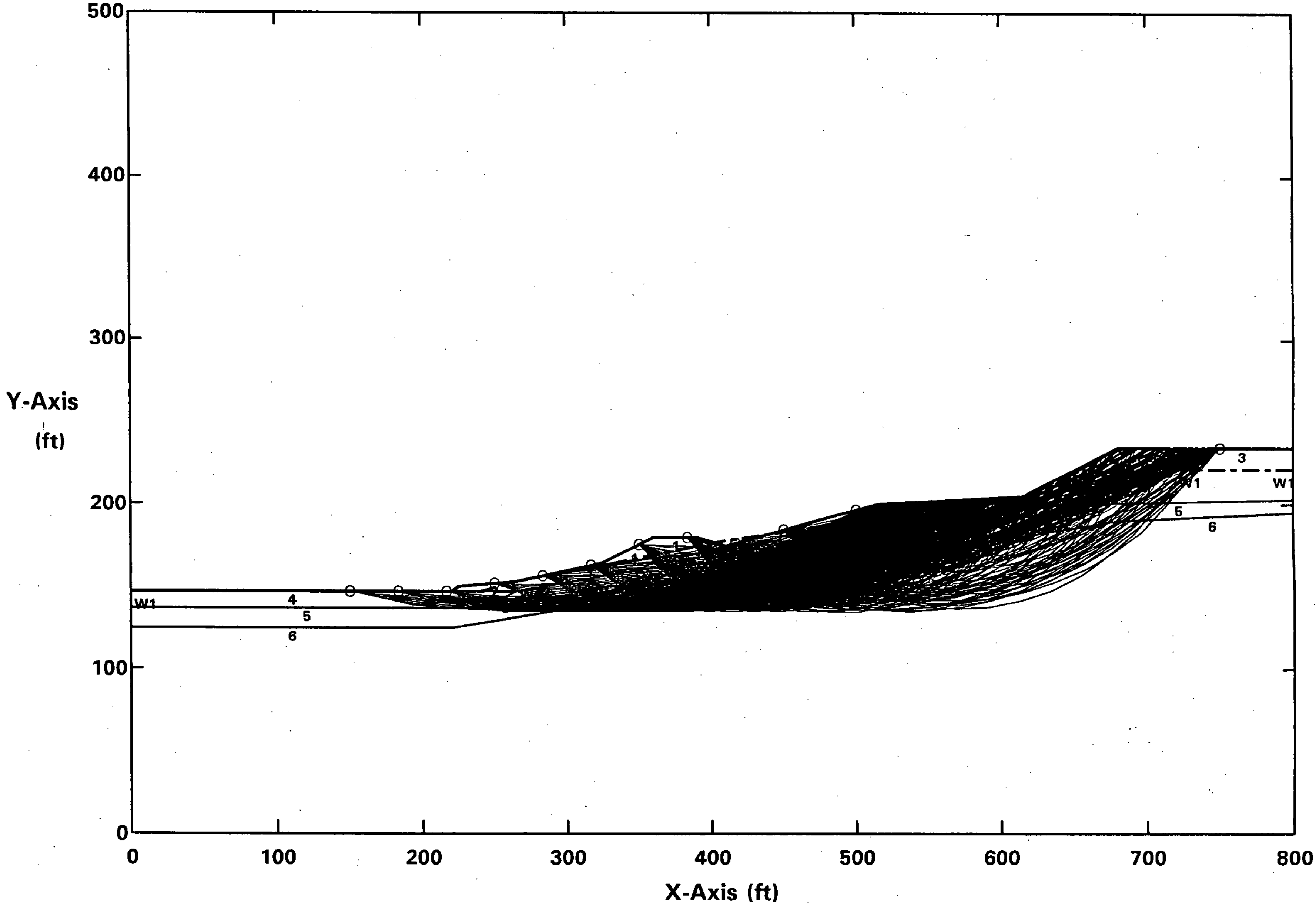
ROCKY FLATS OLF - M&E SECTION B - WCS=15 deg - W/AVEGW - CIRCULAR - 0.02g
Ten Most Critical. C:BEAC02.PLT By: STAN KLINE 10-24-04 3:45am



Label	Soil Type No.	Total Unit Wt. (pcf)	Saturated Unit Wt. (pcf)	Cohesion Intercept (psf)	Friction Angle (deg)	Pore Pressure Param.	Pressure Constant (psf)	Piez. Surface No.
WASTE	1	120	125	50	30	0	0	W1
Qc/SLIDE	2	120	125	0	15	0	0	W1
Qrf	3	120	125	200	30	0	0	W1
Qal	4	125	130	0	33	0	0	W1
WCS	5	120	125	0	15	0	0	W1
UCS	6	125	130	600	30	0	0	W1

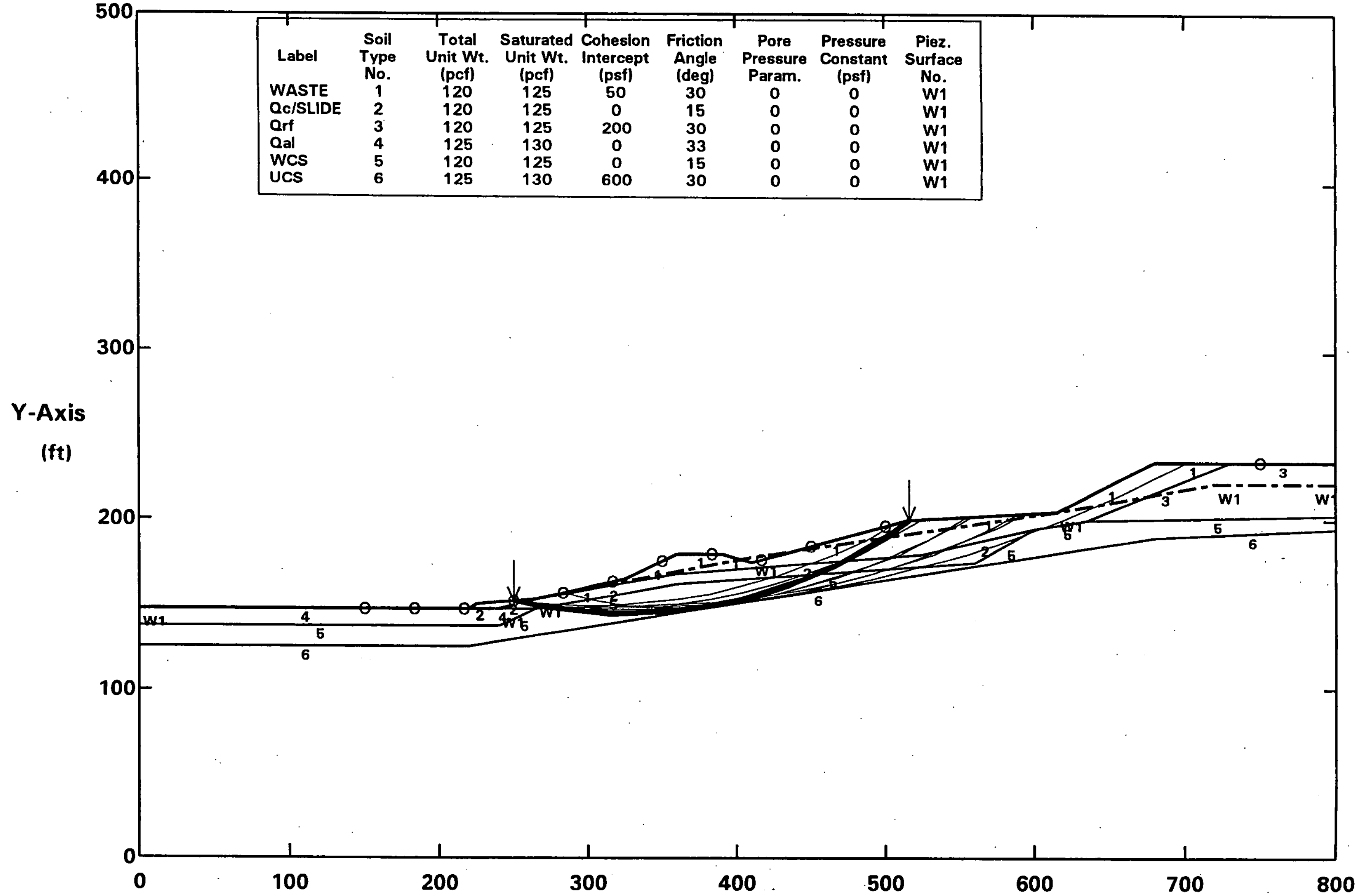
PCSTABL5M/SI FSmin=1.04 X-Axis (ft)
Factors Of Safety Calculated By The Modified Bishop Method

ROCKY FLATS OLF - M&E SECTION B - WCS = 15 deg - W/HIGHGW - CIRCULAR - 0.06g
All surfaces evaluated. C:BEHC06.PLT By: STAN KLINE 10-26-04 12:05am



Factors Of Safety Calculated By The Modified Bishop Method

ROCKY FLATS OLF - M&E SECTION B - WCS = 15 deg - W/HIGHGW - CIRCULAR - 0.06g
Ten Most Critical. C:BEHC06.PLT By: STAN KLINE 10-26-04 12:05am

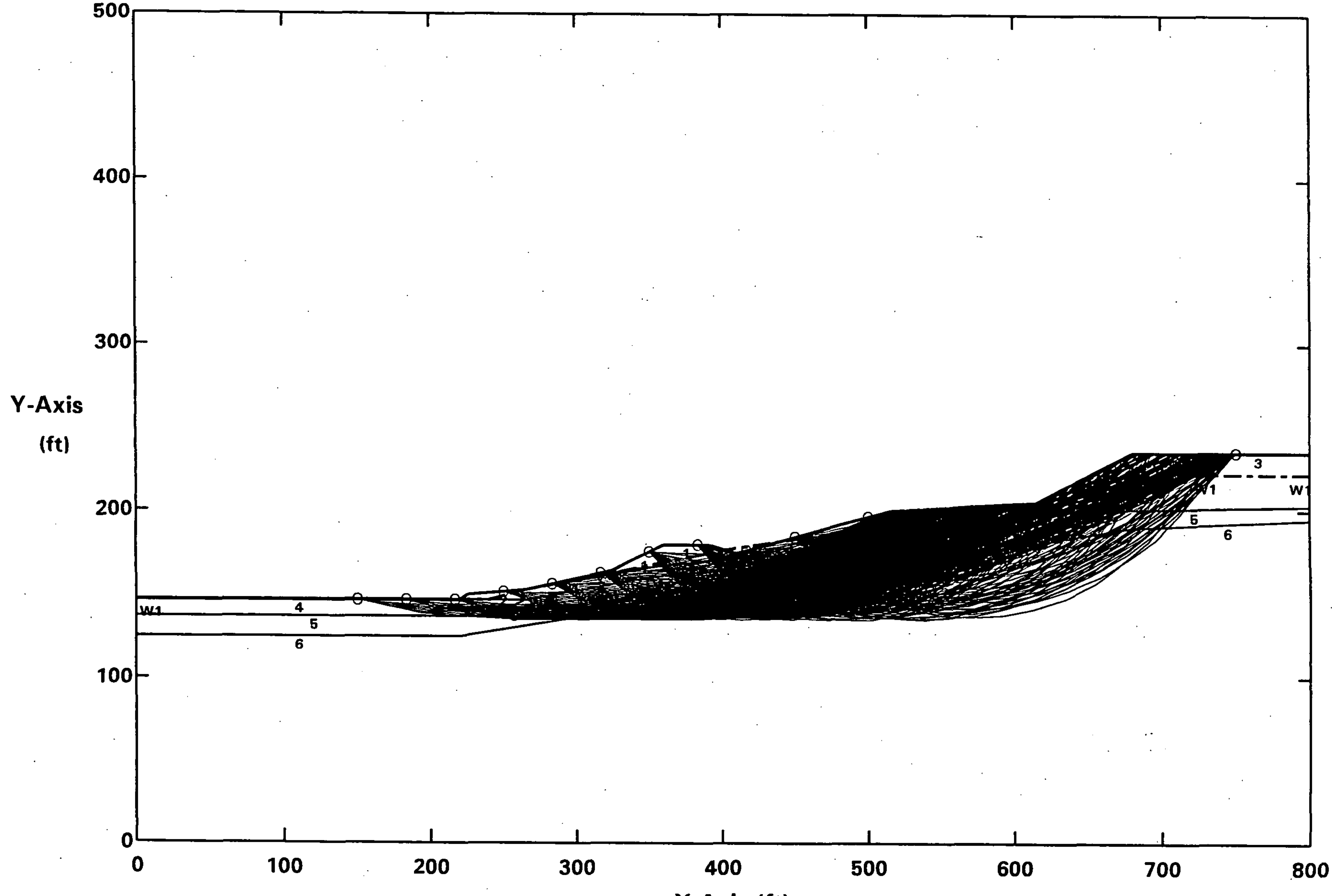


Label	Soil Type No.	Total Unit Wt. (pcf)	Saturated Unit Wt. (pcf)	Cohesion Intercept (psf)	Friction Angle (deg)	Pore Pressure Param.	Pressure Constant (psf)	Piez. Surface No.
WASTE	1	120	125	50	30	0	0	W1
Qc/SLIDE	2	120	125	0	15	0	0	W1
Qrf	3	120	125	200	30	0	0	W1
Qal	4	125	130	0	33	0	0	W1
WCS	5	120	125	0	15	0	0	W1
UCS	6	125	130	600	30	0	0	W1

PCSTABL5M/SI FSmin = 0.78 X-Axis (ft)
Factors Of Safety Calculated By The Modified Bishop Method

20

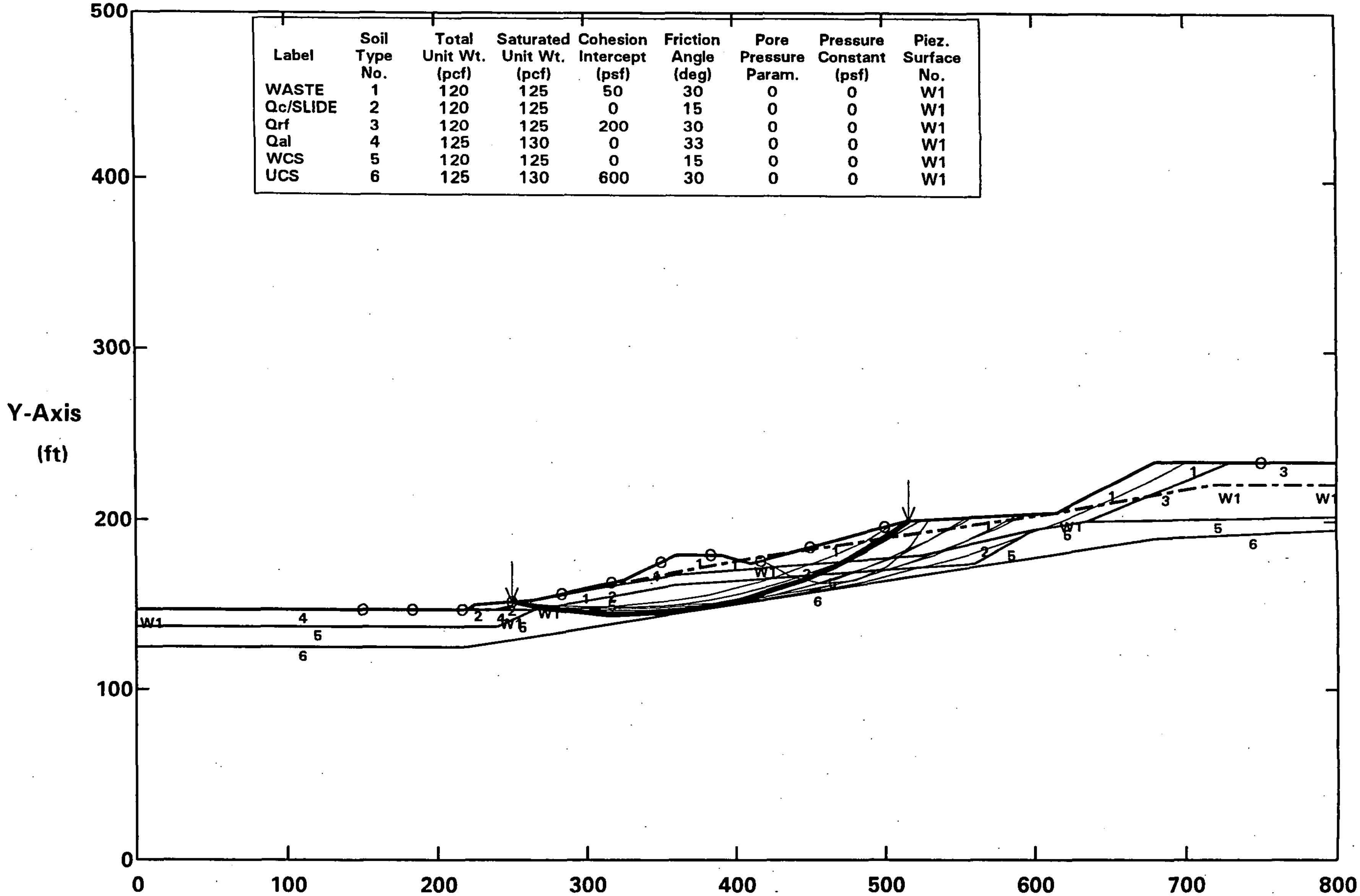
ROCKY FLATS OLF - M&E SECTION B - WCS = 15 deg - W/HIGHGW - CIRCULAR - 0.01g
All surfaces evaluated. C:BEHC01.PLT By: STAN KLINE 10-26-04 12:04am



Factors Of Safety Calculated By The Modified Bishop Method

102

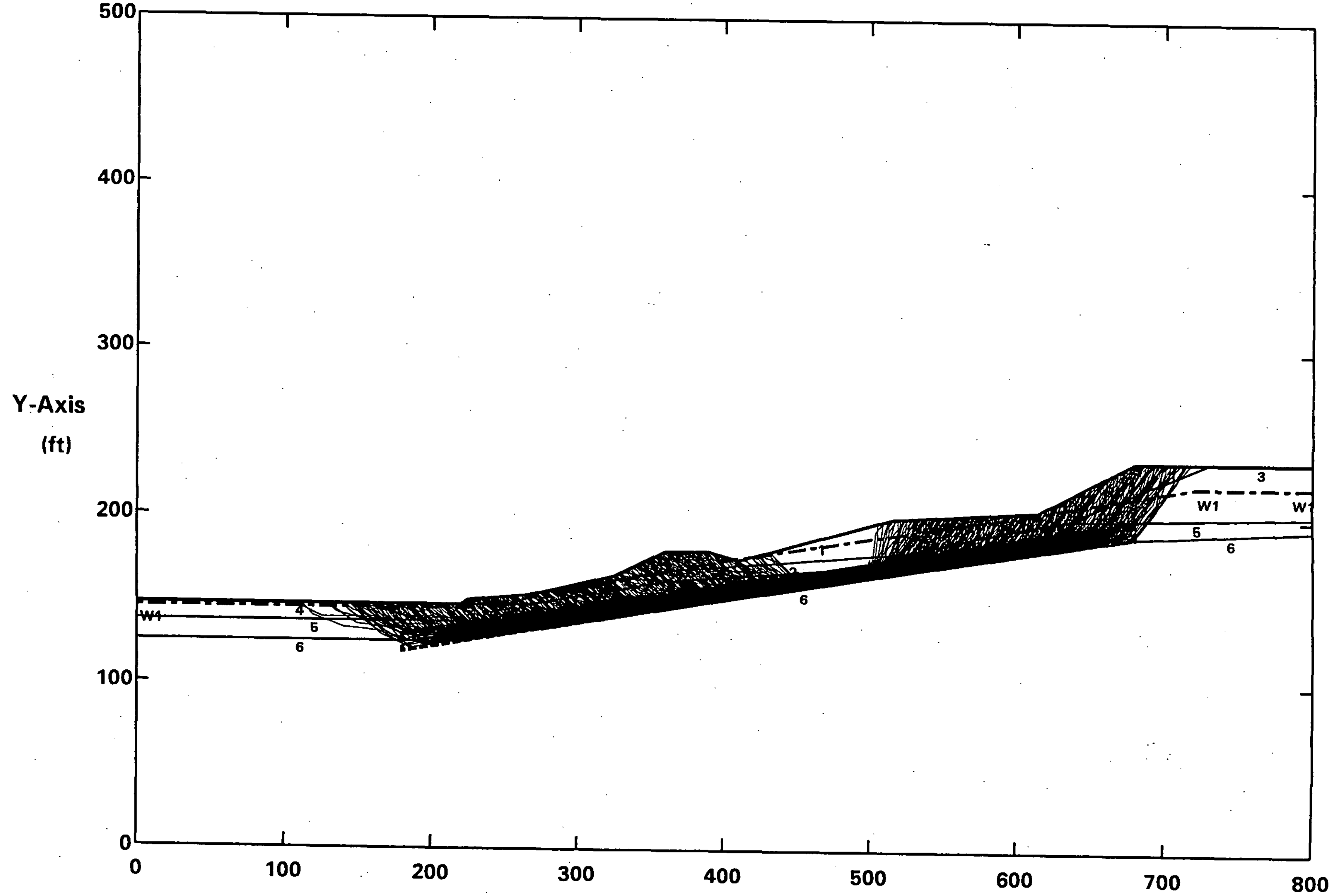
ROCKY FLATS OLF - M&E SECTION B - WCS = 15 deg - W/HIGHGW - CIRCULAR - 0.01g
Ten Most Critical. C:BEHC01.PLT By: STAN KLINE 10-26-04 12:04am



PCSTABL5M/SI FSmin = 1.02 X-Axis (ft)
Factors Of Safety Calculated By The Modified Bishop Method

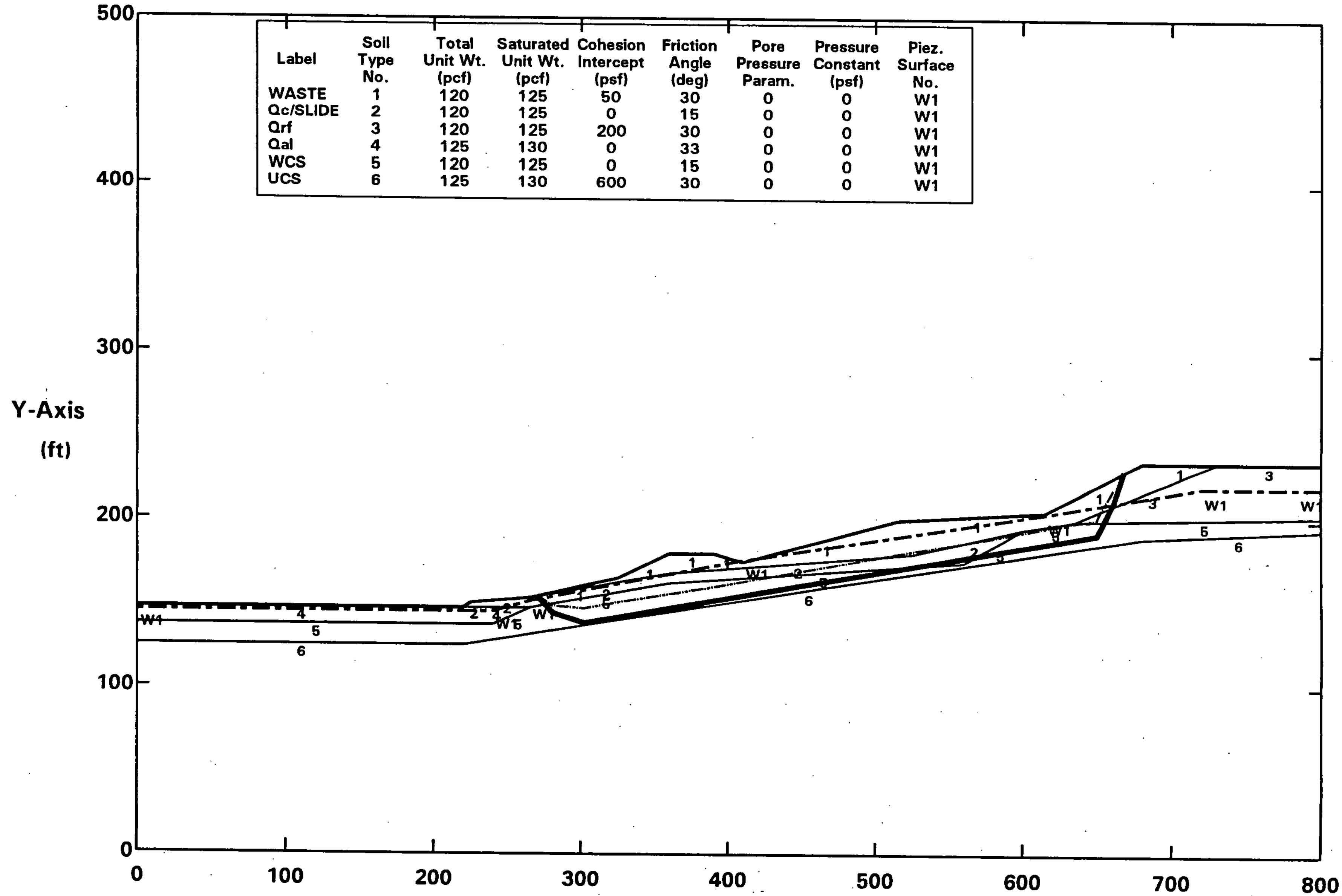
202

ROCKY FLATS OLF - M&E SECTION B - WCS = 15 deg - W/AVEGW - SLIDING BLOCK - 0.06g
All surfaces evaluated. C:BEAS06.PLT By: STAN KLINE 10-24-04 3:53am



Factors Of Safety Calculated By The Modified Janbu Method

ROCKY FLATS OLF - M&E SECTION B - WCS=15 deg - W/AVEGW - SLIDING BLOCK - 0.06g
Surface #1-BEAS06.OUT. C:BEAS06SP.PLT By: STAN KLINE 10-24-04 3:55am

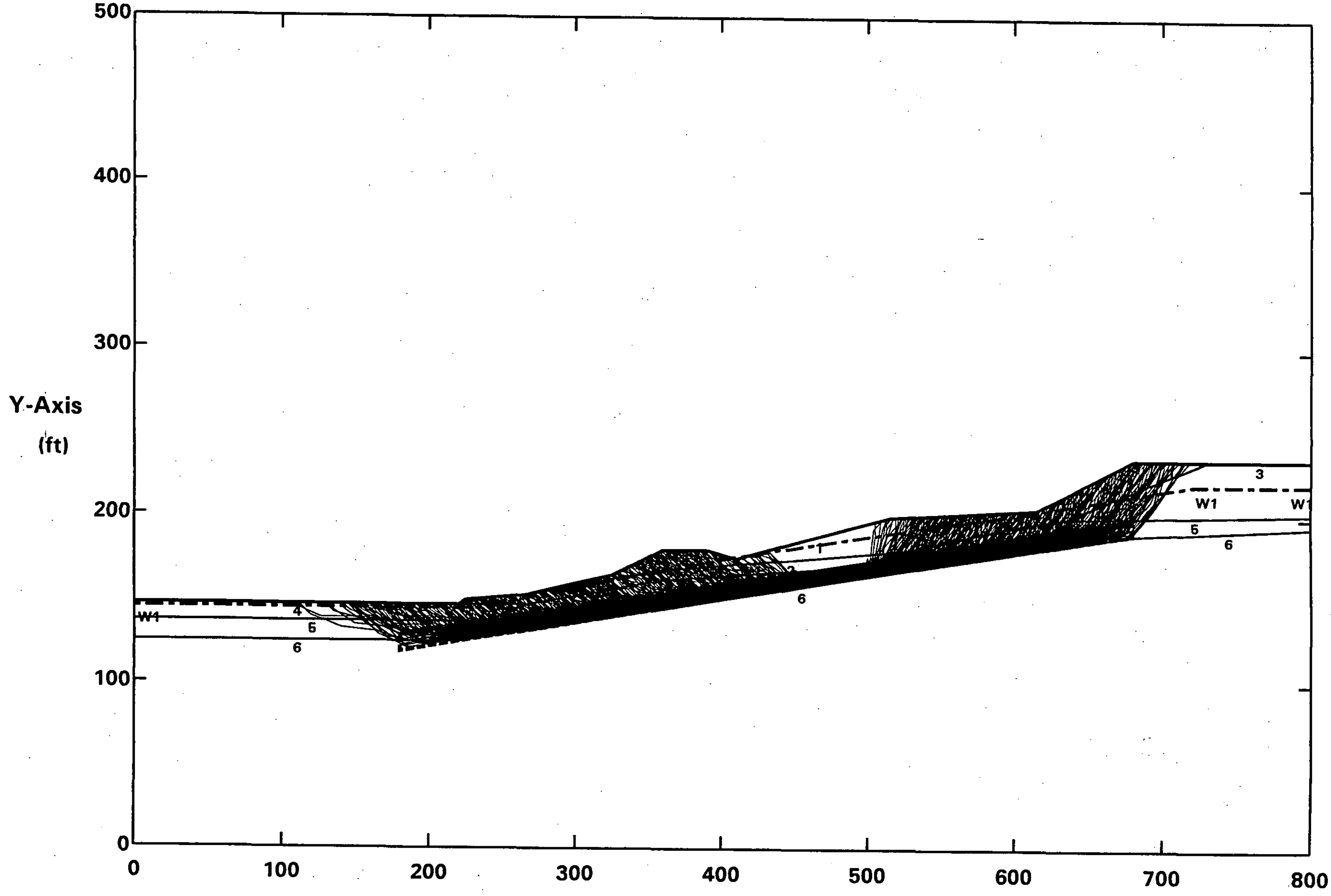


Label	Soil Type No.	Total Unit Wt. (pcf)	Saturated Unit Wt. (pcf)	Cohesion Intercept (psf)	Friction Angle (deg)	Pore Pressure Param.	Pressure Constant (psf)	Piez. Surface No.
WASTE	1	120	125	50	30	0	0	W1
Qc/SLIDE	2	120	125	0	15	0	0	W1
Qrf	3	120	125	200	30	0	0	W1
Qal	4	125	130	0	33	0	0	W1
WCS	5	120	125	0	15	0	0	W1
UCS	6	125	130	600	30	0	0	W1

PCSTABL5M/SI FS=0.79 Theta=8.29 X-Axis (ft)
Factors Of Safety Calculated By Spencer`s Method of Slices

204

ROCKY FLATS OLF - M&E SECTION B - WCS = 15 deg - W/AVEGW - SLIDING BLOCK - 0.01g
All surfaces evaluated. C:BEAS01.PLT By: STAN KLINE 10-24-04 3:59am

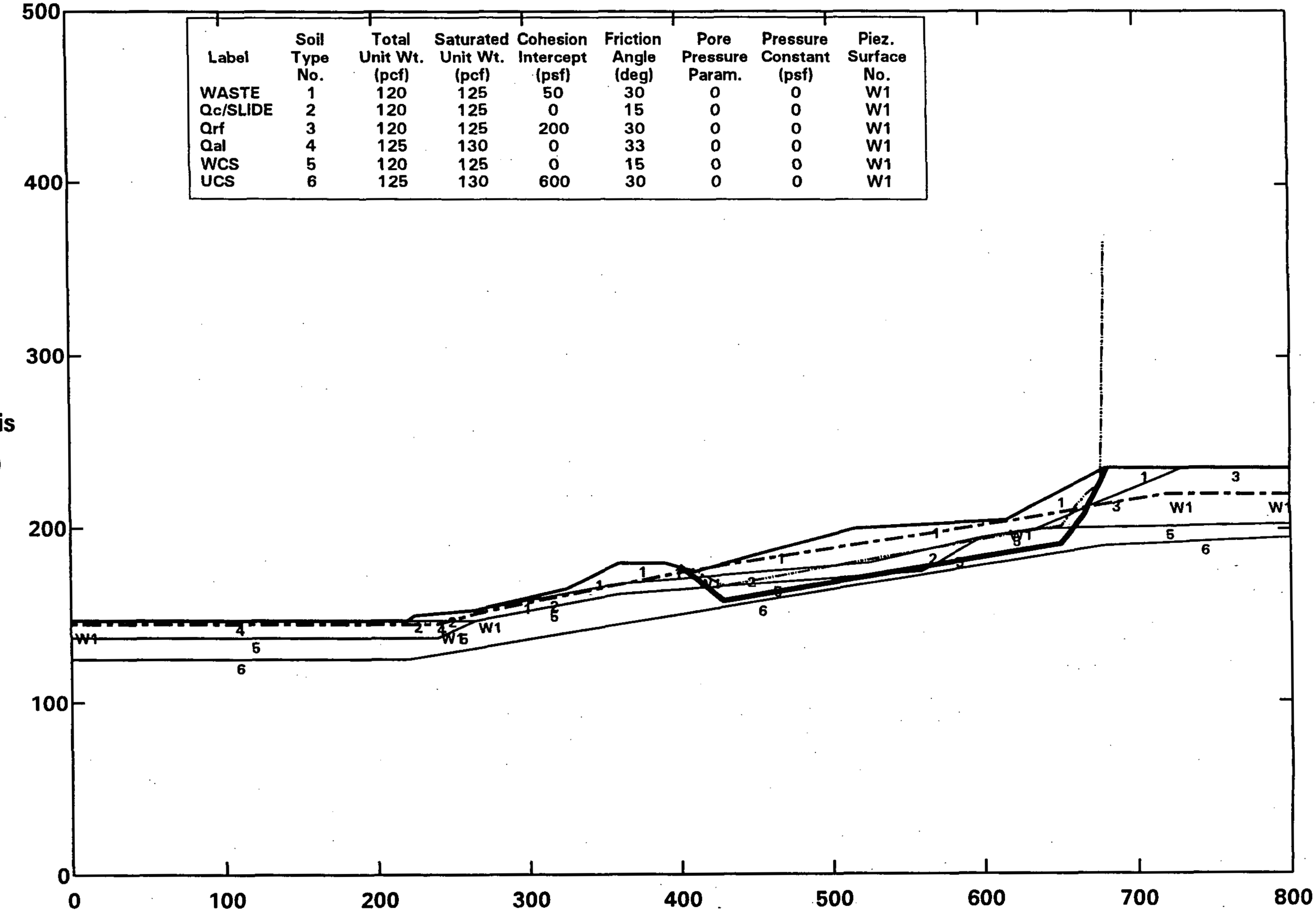


Factors Of Safety Calculated By The Modified Janbu Method

205

ROCKY FLATS OLF - M&E SECTION B - WCS=15 deg - W/AVEGW - SLIDING BLOCK - 0.01g
Surface #1-BEAS01.OUT. C:BEAS01SP.PLT By: STAN KLINE 10-24-04 4:00am

Y-Axis (ft)

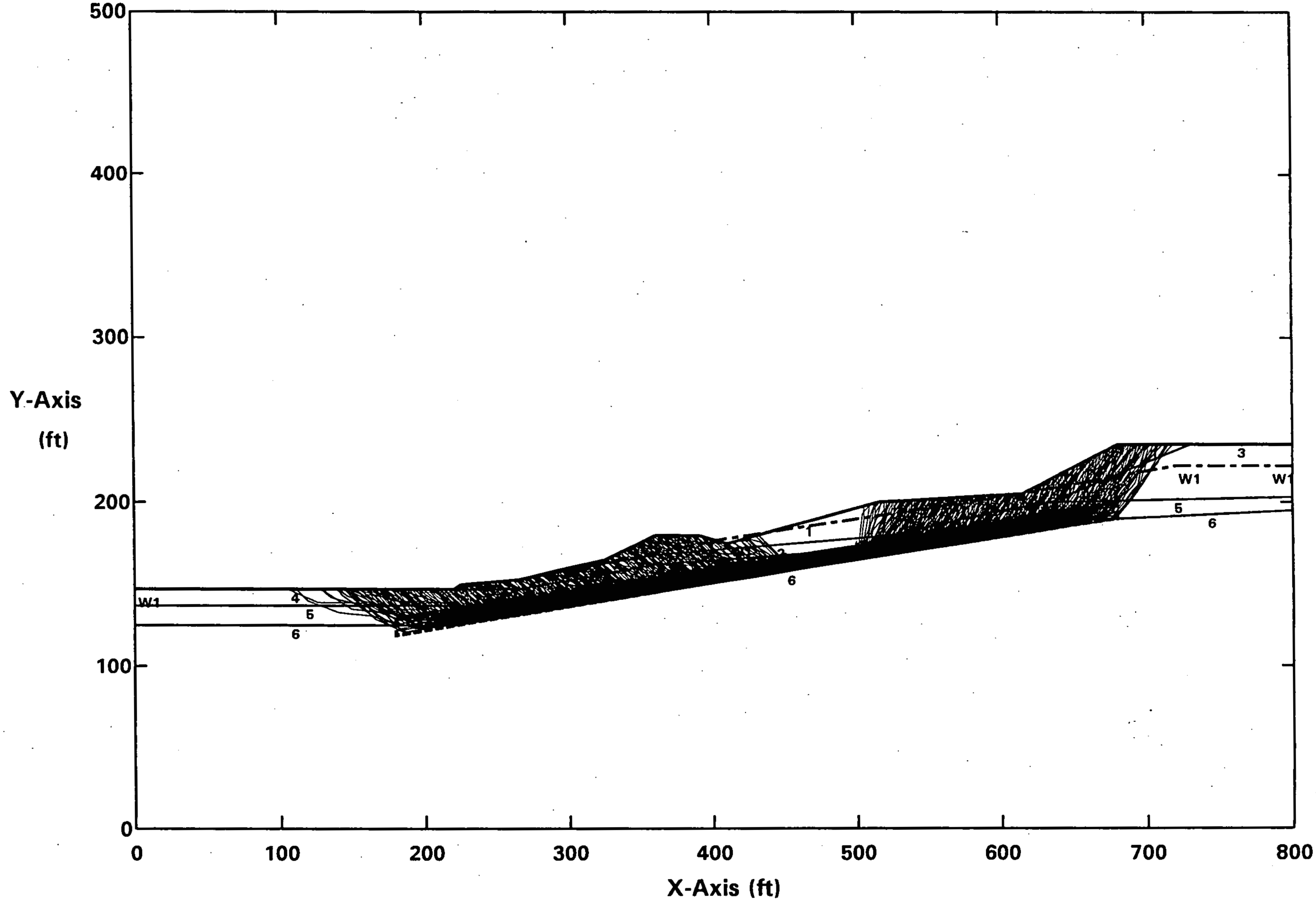


Label	Soil Type No.	Total Unit Wt. (pcf)	Saturated Unit Wt. (pcf)	Cohesion Intercept (psf)	Friction Angle (deg)	Pore Pressure Param.	Pressure Constant (psf)	Piez. Surface No.
WASTE	1	120	125	50	30	0	0	W1
Qc/SLIDE	2	120	125	0	15	0	0	W1
Qrf	3	120	125	200	30	0	0	W1
Qal	4	125	130	0	33	0	0	W1
WCS	5	120	125	0	15	0	0	W1
UCS	6	125	130	600	30	0	0	W1

PCSTABL5M/SI FS=1.04 Theta=8.8 X-Axis (ft)
Factors Of Safety Calculated By Spencer`s Method of Slices

206

ROCKY FLATS OLF - M&E SECTION B - WCS=15 deg - W/HIGHGW - SLIDING BLOCK - 0.06g
All surfaces evaluated. C:BEHS06.PLT By: STAN KLINE 10-24-04 5:51pm

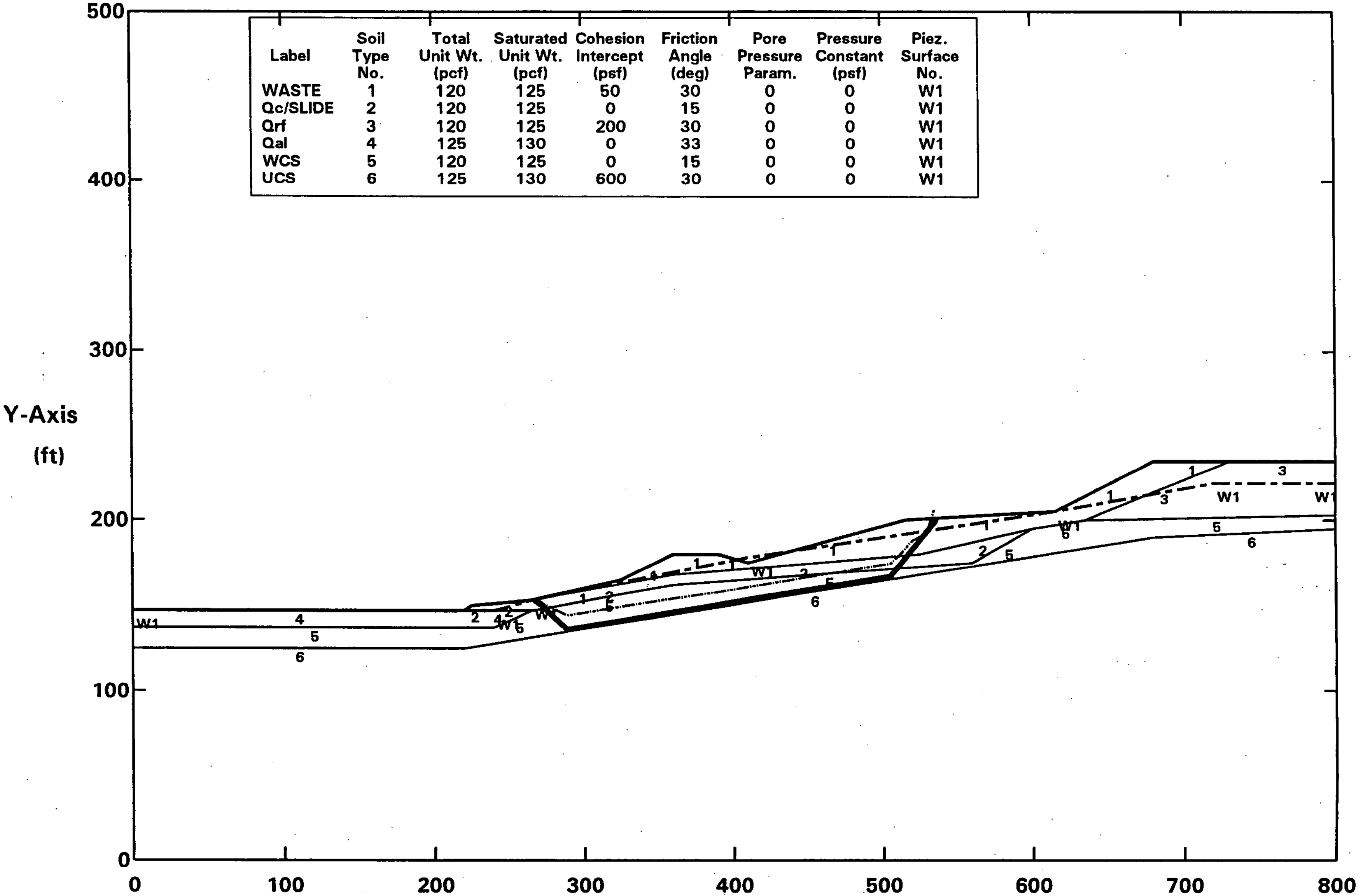


Factors Of Safety Calculated By The Modified Janbu Method

207

ROCKY FLATS OLF - M&E SECTION B - WCS = 15 deg - W/HIGHGW - SLIDING BLOCK - 0.06g
Surface #1-BEHS06.OUT. C:BEHS06SP.PLT By: STAN KLINE 10-24-04 5:54pm

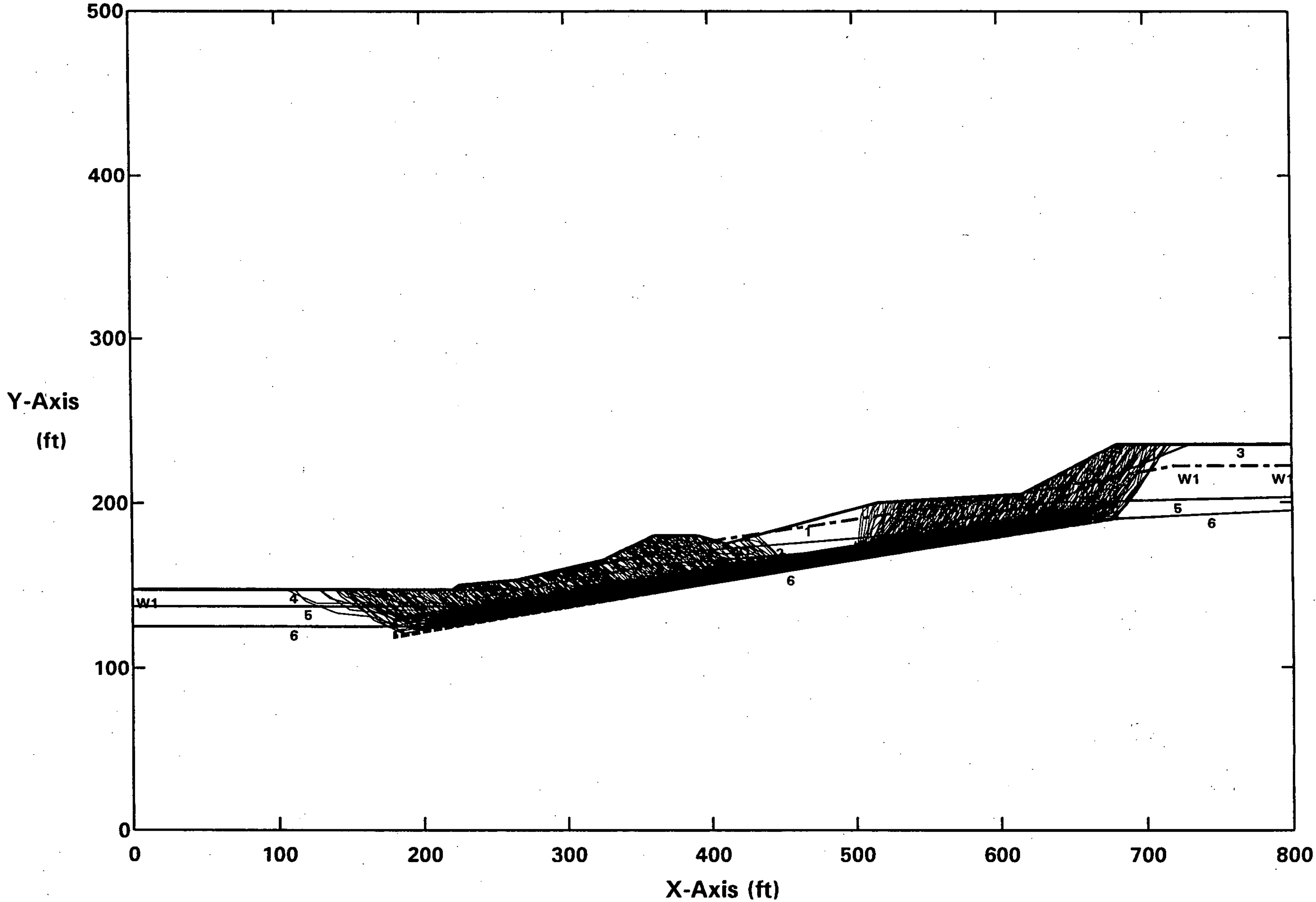
Label	Soil Type No.	Total Unit Wt. (pcf)	Saturated Unit Wt. (pcf)	Cohesion Intercept (psf)	Friction Angle (deg)	Pore Pressure Param.	Pressure Constant (psf)	Piez. Surface No.
WASTE	1	120	125	50	30	0	0	W1
Qc/SLIDE	2	120	125	0	15	0	0	W1
Qrf	3	120	125	200	30	0	0	W1
Qal	4	125	130	0	33	0	0	W1
WCS	5	120	125	0	15	0	0	W1
UCS	6	125	130	600	30	0	0	W1



PCSTABL5M/SI FS = 0.76 Theta = 7.76 X-Axis (ft)
Factors Of Safety Calculated By Spencer`s Method of Slices

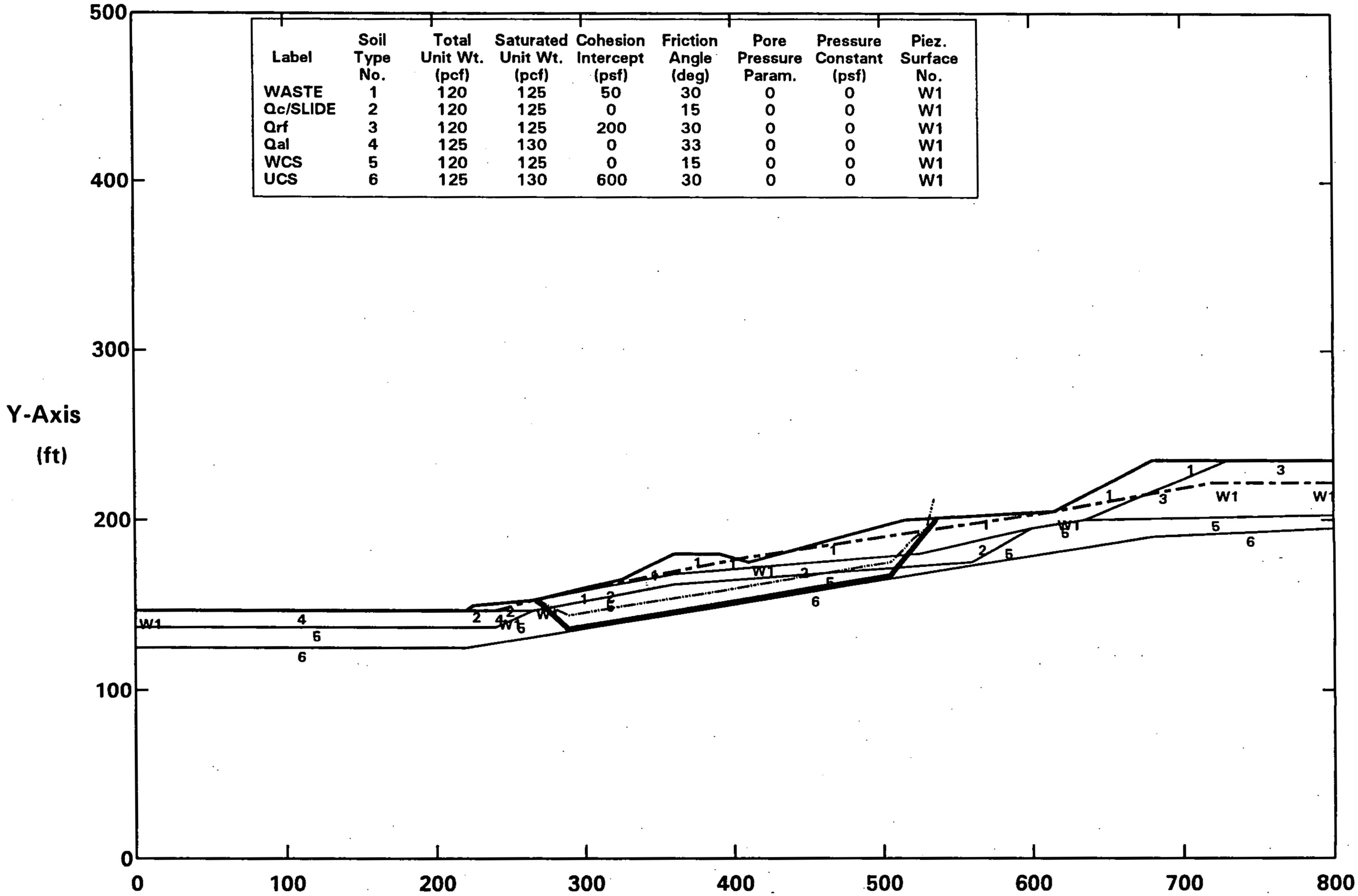
208

ROCKY FLATS OLF - M&E SECTION B - WCS = 15 deg - W/HIGHGW - SLIDING BLOCK - 0.009g
All surfaces evaluated. C:BEHS01.PLT By: STAN KLINE 10-26-04 12:51am



Factors Of Safety Calculated By The Modified Janbu Method

ROCKY FLATS OLF - M&E SECTION B - WCS=15 deg - W/HIGHGW - SLIDING BLOCK - 0.009g
Surface #1-BEHS01.OUT. C:BEHS01SP.PLT By: STAN KLINE 10-26-04 12:51am



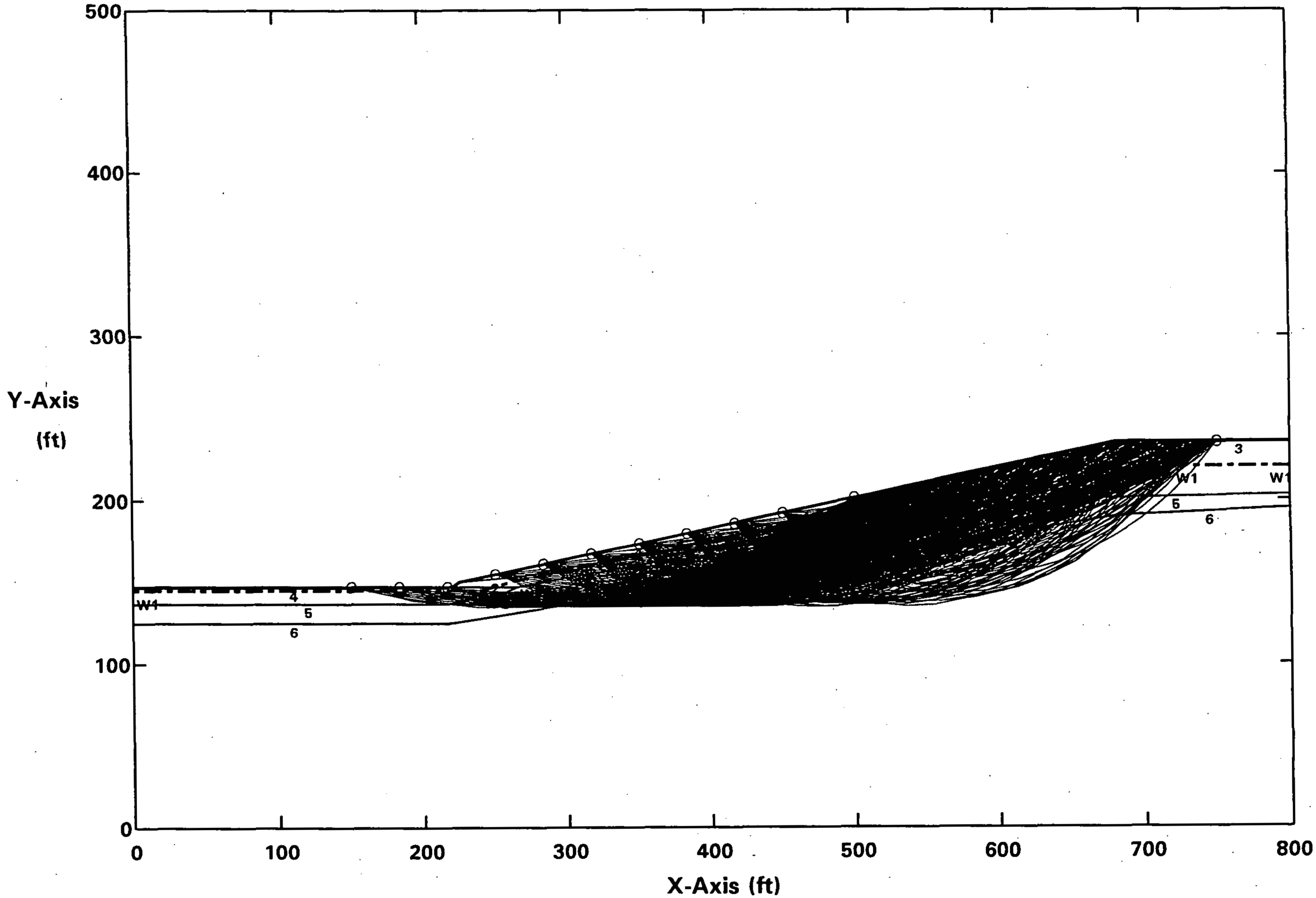
Label	Soil Type No.	Total Unit Wt. (pcf)	Saturated Unit Wt. (pcf)	Cohesion Intercept (psf)	Friction Angle (deg)	Pore Pressure Param.	Pressure Constant (psf)	Piez. Surface No.
WASTE	1	120	125	50	30	0	0	W1
Qc/SLIDE	2	120	125	0	15	0	0	W1
Qrf	3	120	125	200	30	0	0	W1
Qal	4	125	130	0	33	0	0	W1
WCS	5	120	125	0	15	0	0	W1
UCS	6	125	130	600	30	0	0	W1

PCSTABL5M/SI FS=1.00 Theta=8.1 X-Axis (ft)
Factors Of Safety Calculated By Spencer`s Method of Slices

18% REGRADE CONDITION

210

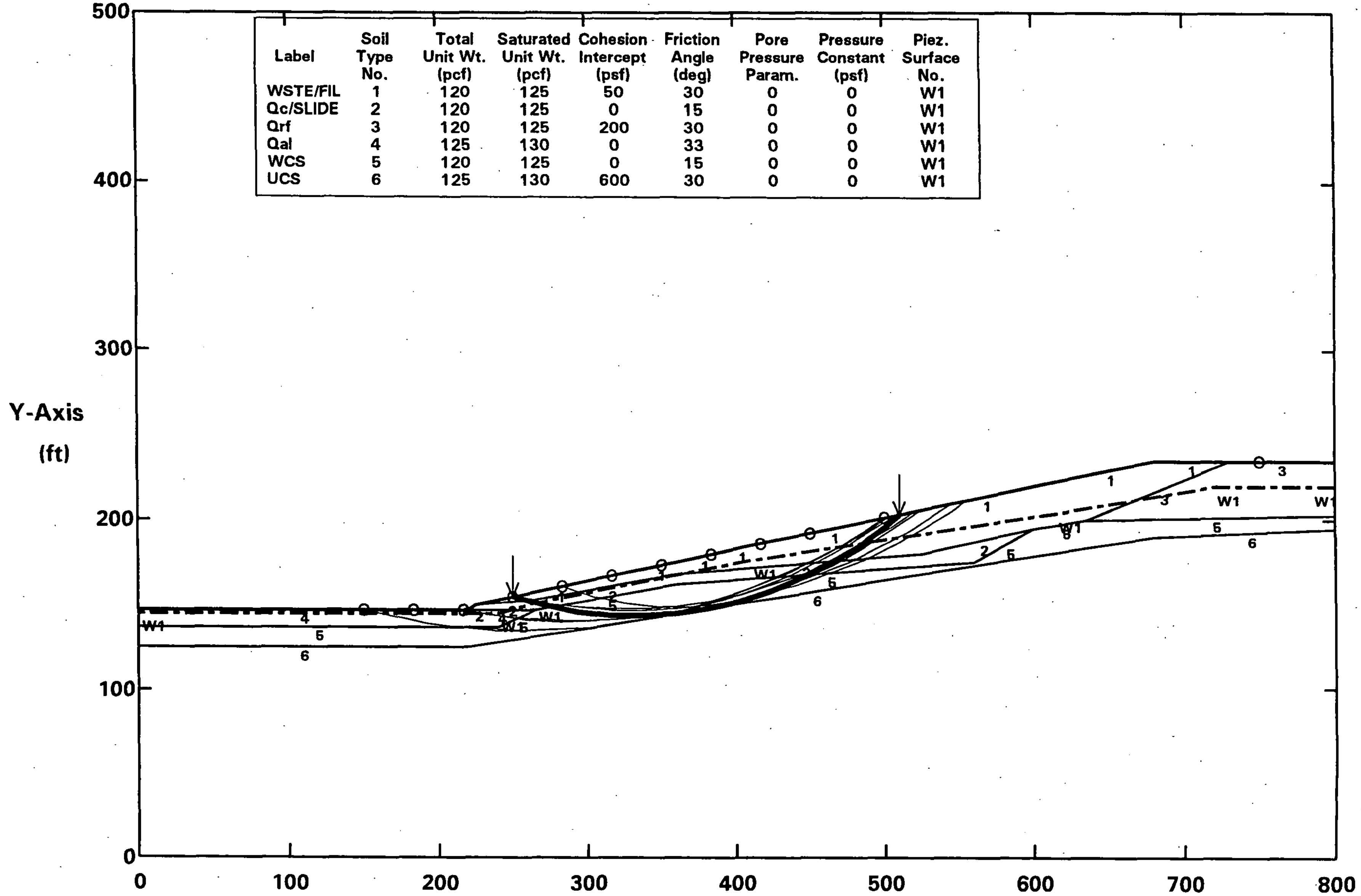
ROCKY FLATS OLF - M&E B 18% GRD - WCS=15 deg - W/AVEGW - CIRCULAR - 0.06g
All surfaces evaluated. C:BGAC06.PLT By: STAN KLINE 10-26-04 12:02am



Factors Of Safety Calculated By The Modified Bishop Method

212

ROCKY FLATS OLF - M&E B 18% GRD - WCS=15 deg - W/AVEGW - CIRCULAR - 0.06g
Ten Most Critical. C:BGAC06.PLT By: STAN KLINE 10-26-04 12:02am

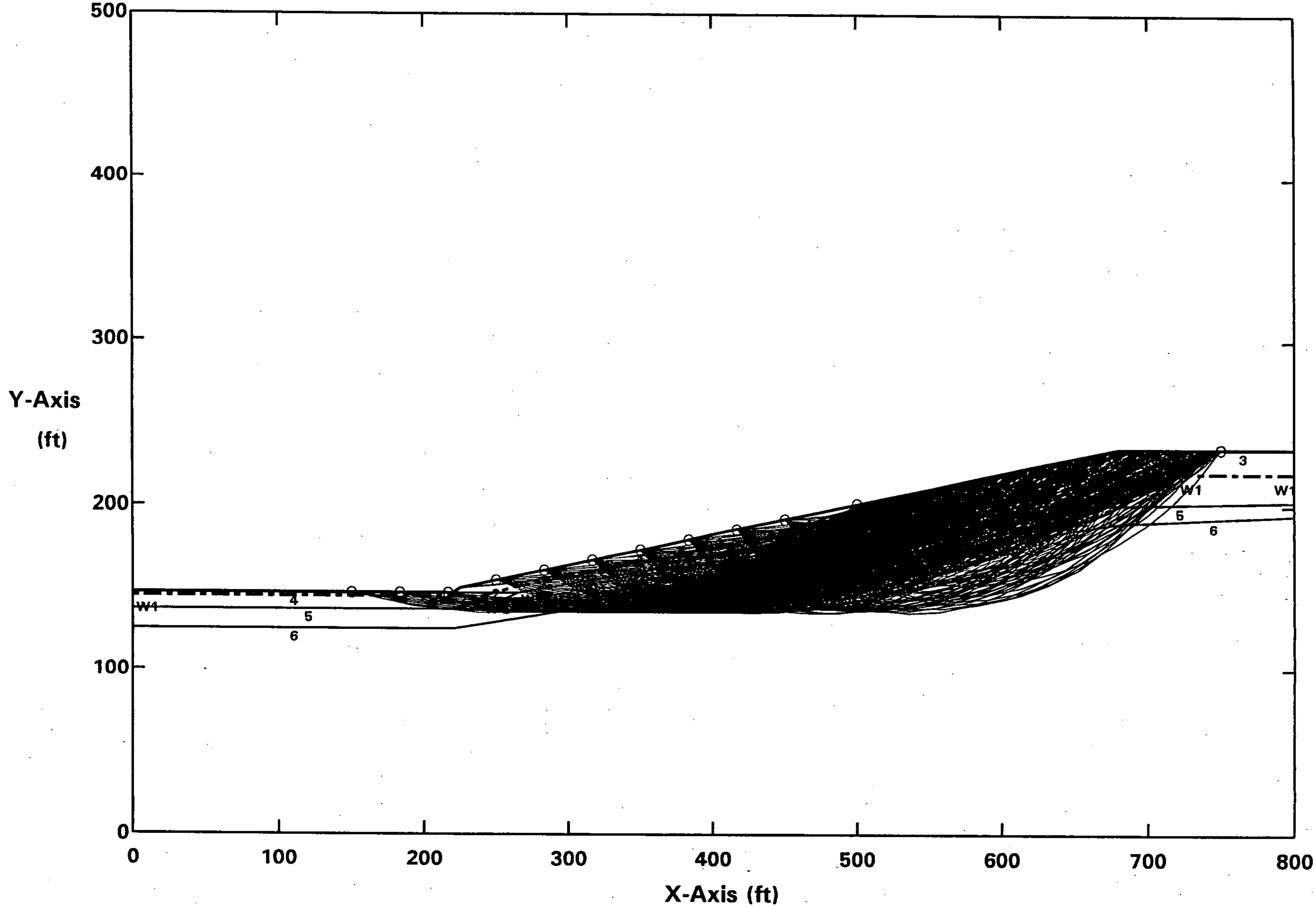


Label	Soil Type No.	Total Unit Wt. (pcf)	Saturated Unit Wt. (pcf)	Cohesion Intercept (psf)	Friction Angle (deg)	Pore Pressure Param.	Pressure Constant (psf)	Piez. Surface No.
WSTE/FIL	1	120	125	50	30	0	0	W1
Qc/SLIDE	2	120	125	0	15	0	0	W1
Qrf	3	120	125	200	30	0	0	W1
Qal	4	125	130	0	33	0	0	W1
WCS	5	120	125	0	15	0	0	W1
UCS	6	125	130	600	30	0	0	W1

PCSTABL5M/SI FSmin=0.90 X-Axis (ft)
Factors Of Safety Calculated By The Modified Bishop Method

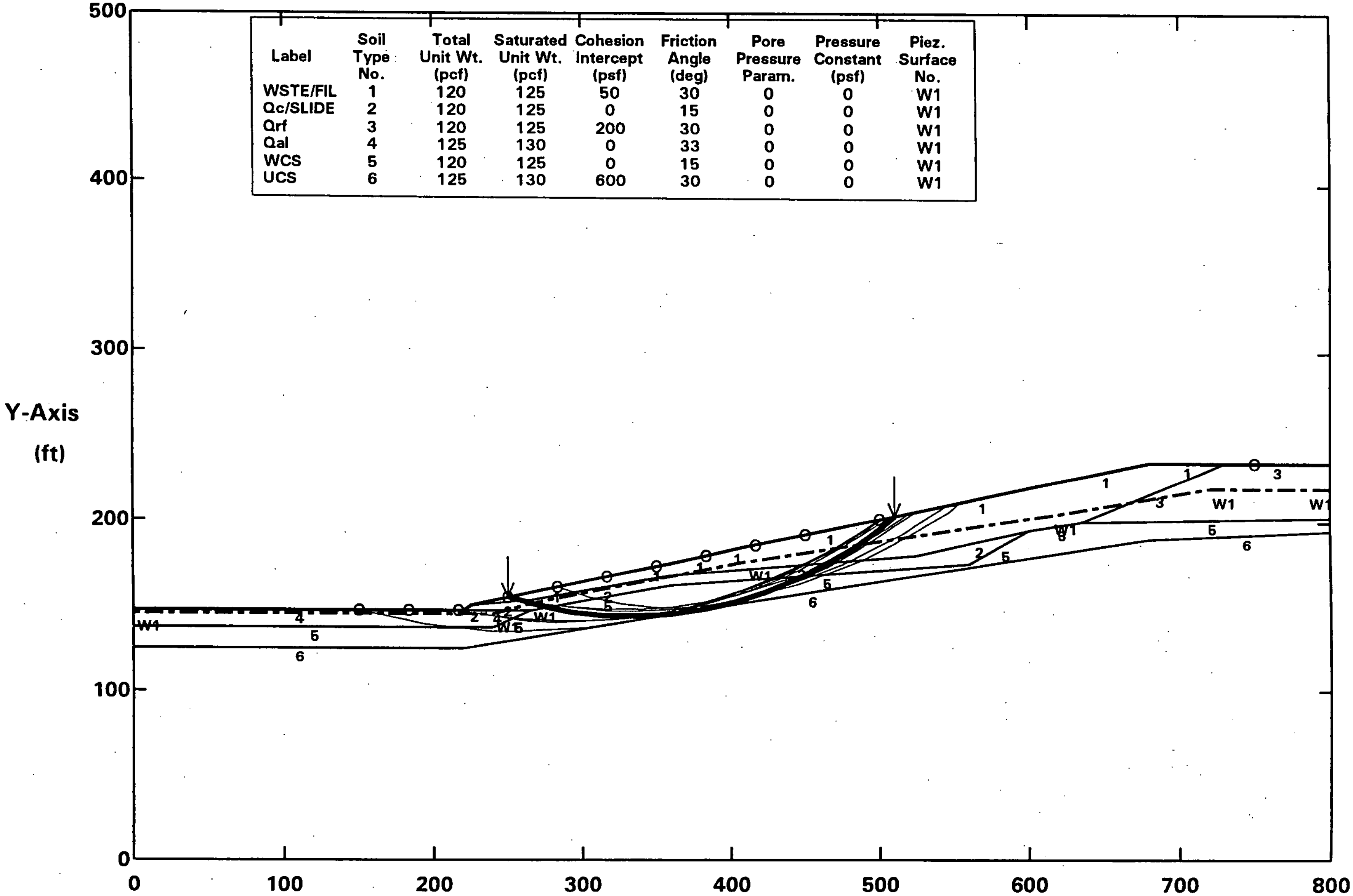
213

ROCKY FLATS OLF - M&E B 18% GRD - WCS = 15 deg - W/AVEGW - CIRCULAR - 0.03g
All surfaces evaluated. C:BGAC03.PLT By: STAN KLINE 10-26-04 12:01am



Factors Of Safety Calculated By The Modified Bishop Method

ROCKY FLATS OLF - M&E B 18% GRD - WCS = 15 deg - W/AVEGW - CIRCULAR - 0.03g
Ten Most Critical. C:BGAC03.PLT By: STAN KLINE 10-26-04 12:01am

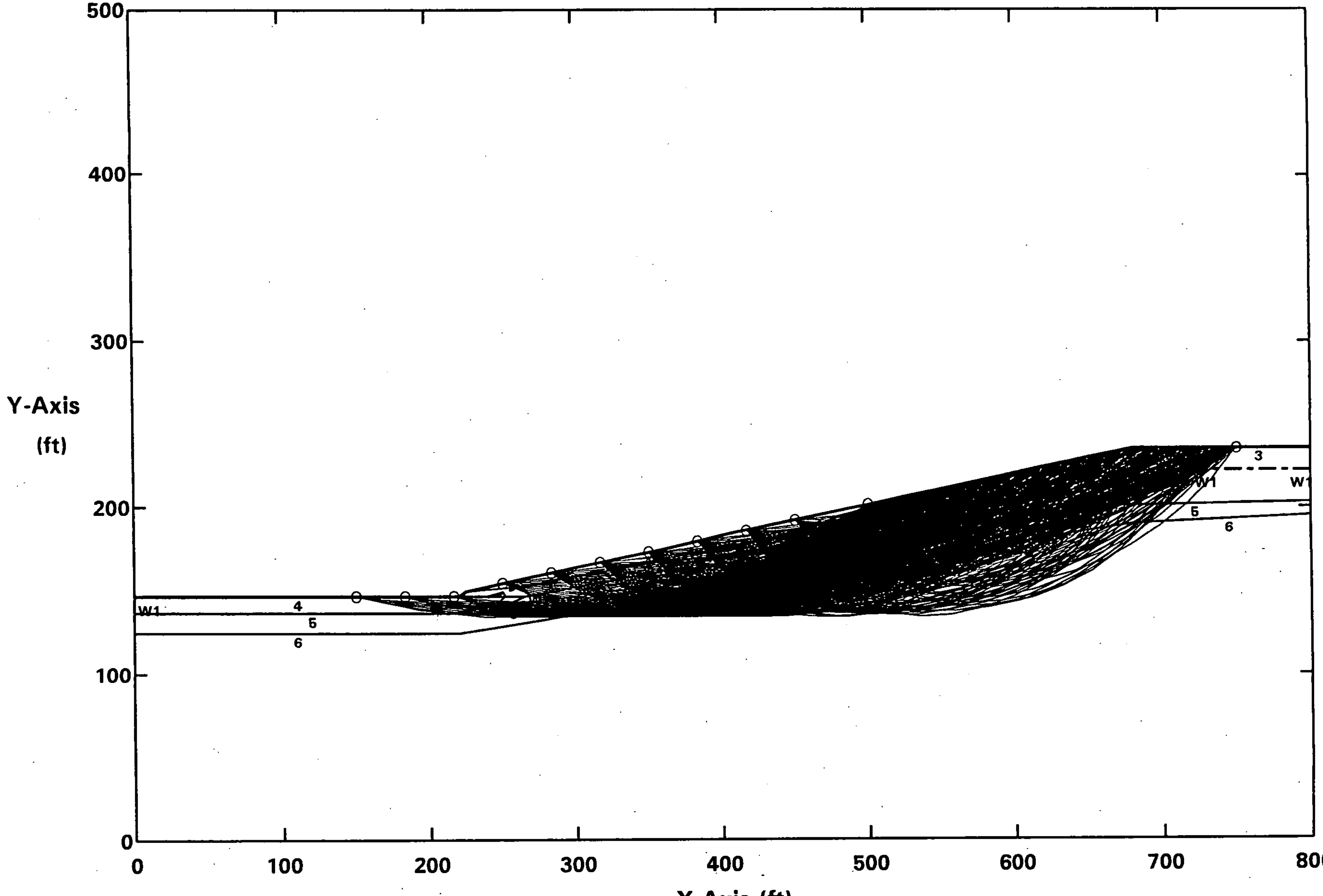


Label	Soil Type No.	Total Unit Wt. (pcf)	Saturated Unit Wt. (pcf)	Cohesion Intercept (psf)	Friction Angle (deg)	Pore Pressure Param.	Pressure Constant (psf)	Piez. Surface No.
WSTE/FIL	1	120	125	50	30	0	0	W1
Qc/SLIDE	2	120	125	0	15	0	0	W1
Qrf	3	120	125	200	30	0	0	W1
Qal	4	125	130	0	33	0	0	W1
WCS	5	120	125	0	15	0	0	W1
UCS	6	125	130	600	30	0	0	W1

PCSTABL5M/SI FSmin = 1.04 X-Axis (ft)
Factors Of Safety Calculated By The Modified Bishop Method

215

ROCKY FLATS OLF - M&E B 18% GRD - WCS=15 deg - W/HIGHGW - CIRCULAR - 0.06g
All surfaces evaluated. C:BGHC06.PLT By: STAN KLINE 10-26-04 12:07am



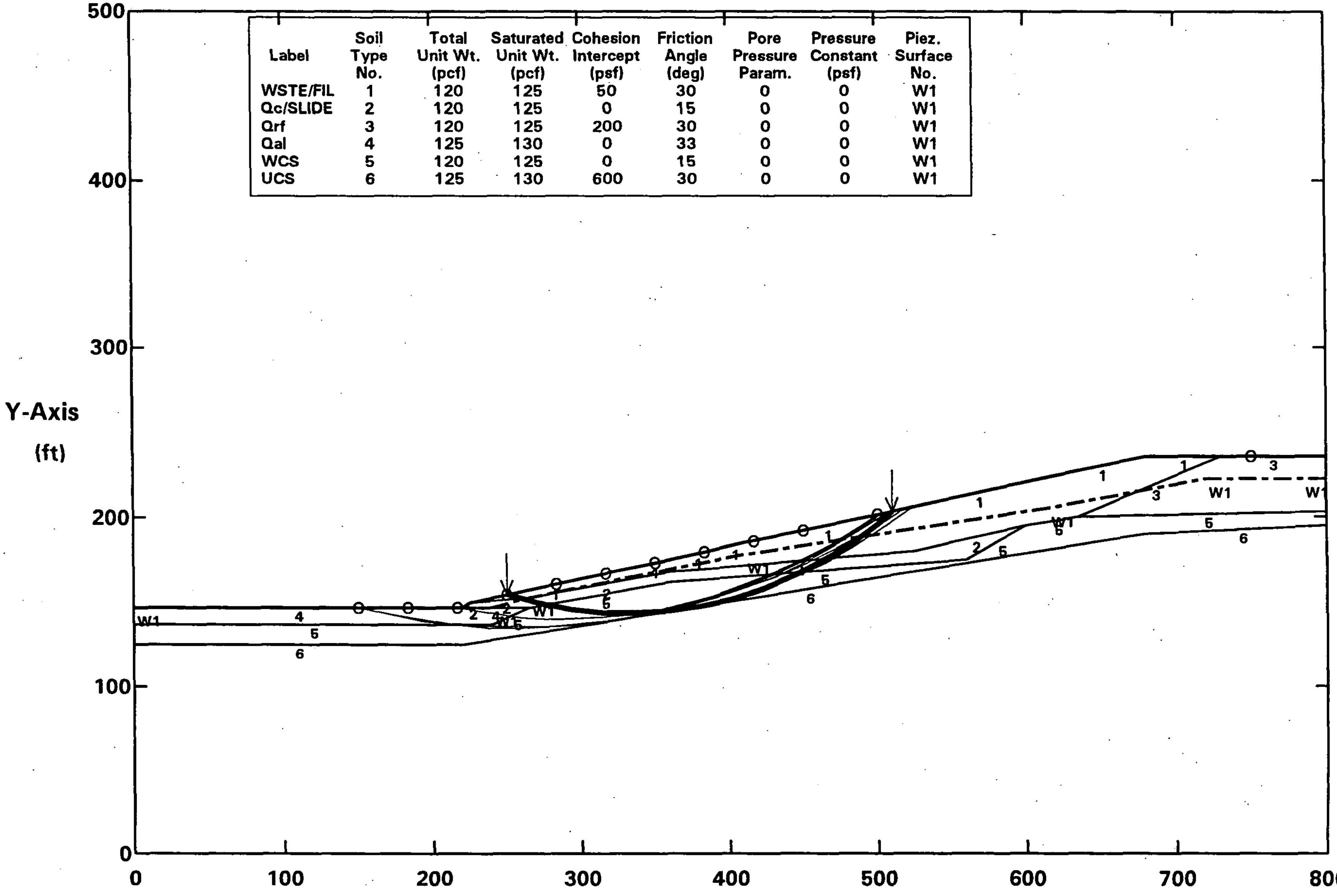
Factors Of Safety Calculated By The Modified Bishop Method

216

ROCKY FLATS OLF - M&E B 18% GRD - WCS = 15 deg - W/HIGHGW - CIRCULAR - 0.06g

Ten Most Critical. C:BGHC06.PLT By: STAN KLINE 10-26-04 12:07am

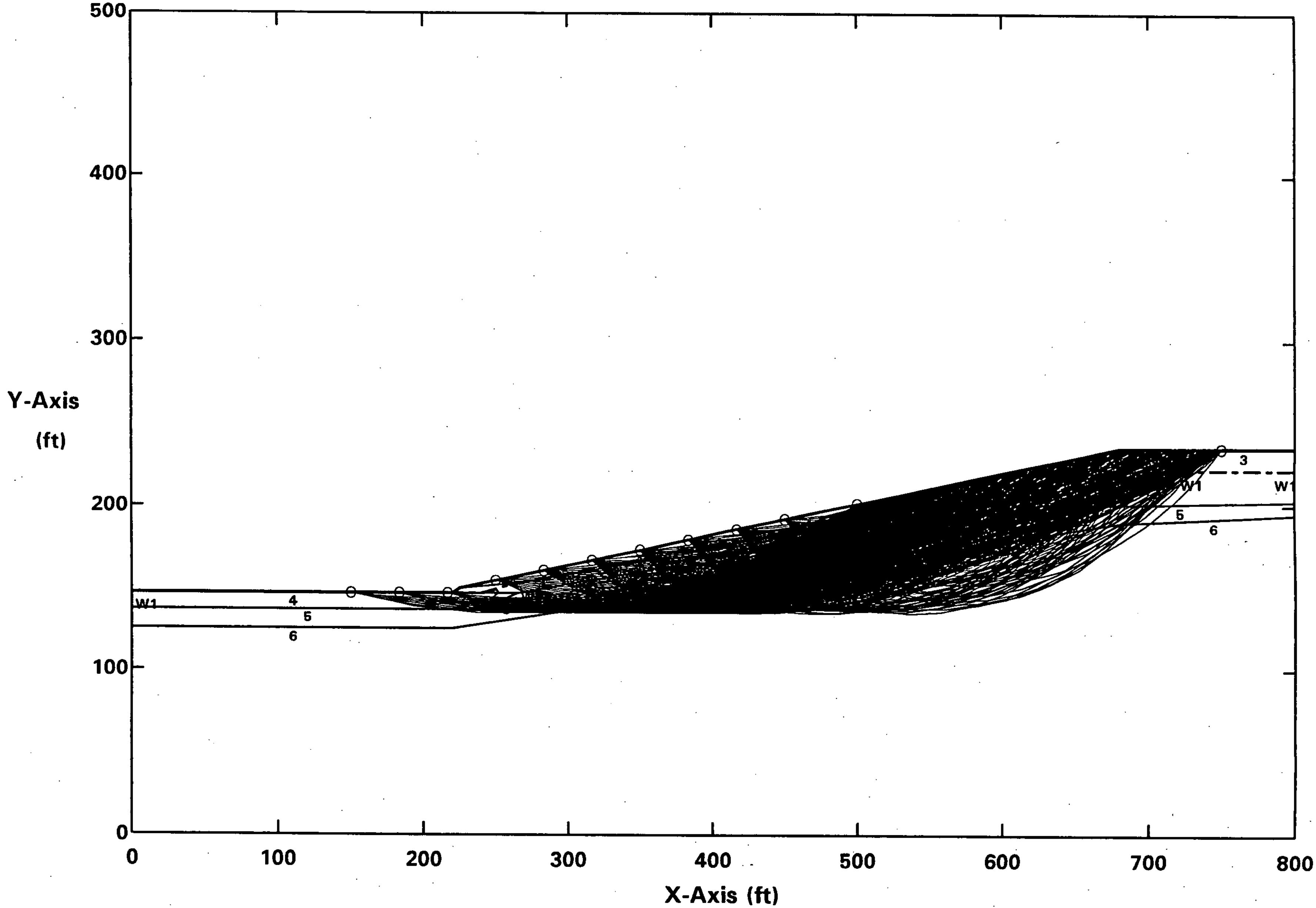
Label	Soil Type No.	Total Unit Wt. (pcf)	Saturated Unit Wt. (pcf)	Cohesion Intercept (psf)	Friction Angle (deg)	Pore Pressure Param.	Pressure Constant (psf)	Piez. Surface No.
WSTE/FIL	1	120	125	50	30	0	0	W1
Qc/SLIDE	2	120	125	0	15	0	0	W1
Qrf	3	120	125	200	30	0	0	W1
Qal	4	125	130	0	33	0	0	W1
WCS	5	120	125	0	15	0	0	W1
UCS	6	125	130	600	30	0	0	W1



PCSTABL5M/SI FSmin = 0.85 X-Axis (ft)

Factors Of Safety Calculated By The Modified Bishop Method

ROCKY FLATS OLF - M&E B 18% GRD - WCS = 15 deg - W/HIGHGW - CIRCULAR - 0.02g
All surfaces evaluated. C:BGHC02.PLT By: STAN KLINE 10-26-04 12:06am

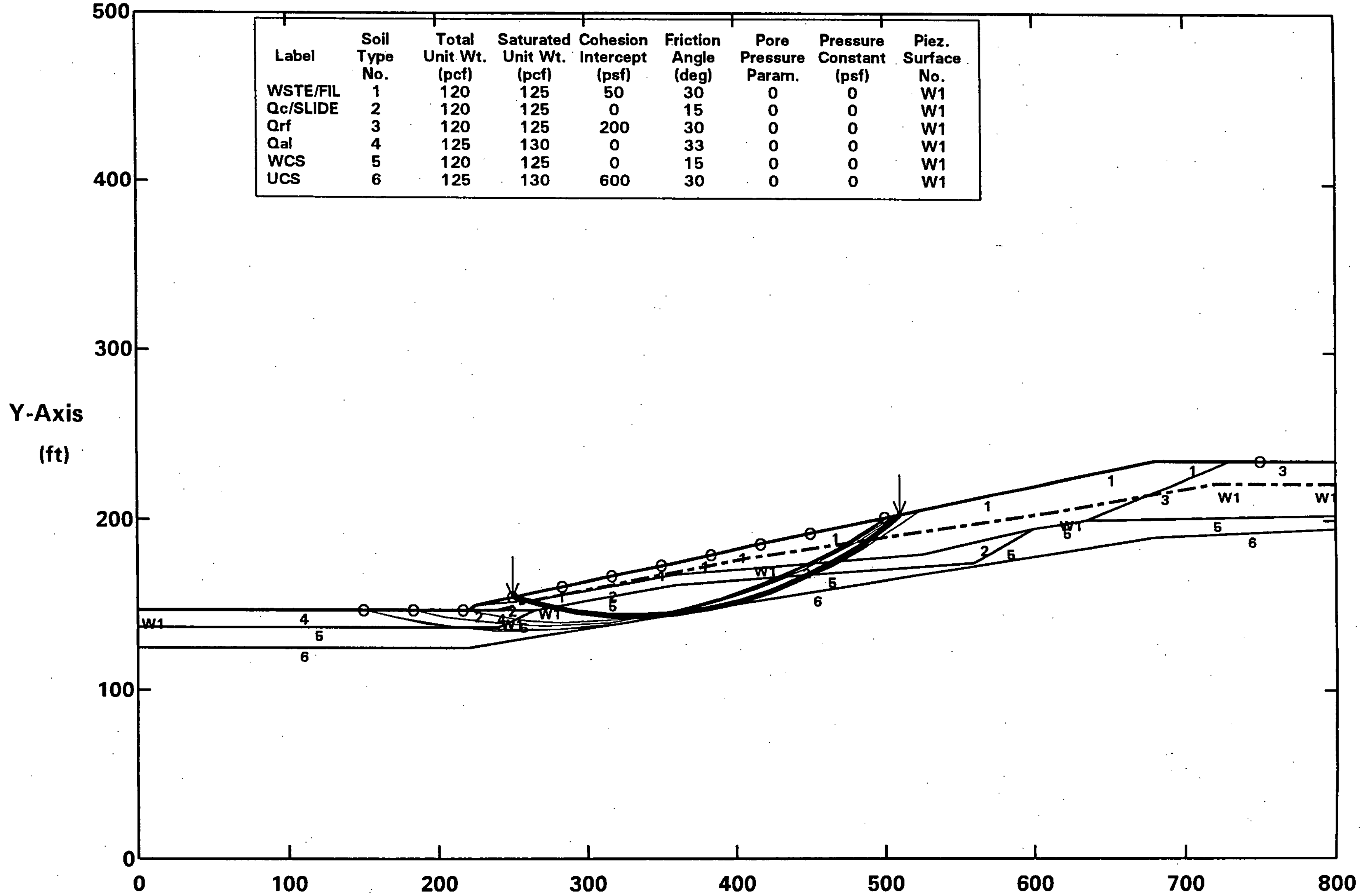


Factors Of Safety Calculated By The Modified Bishop Method

218

ROCKY FLATS OLF - M&E B 18% GRD - WCS = 15 deg - W/HIGHGW - CIRCULAR - 0.02g
Ten Most Critical. C:BGHC02.PLT By: STAN KLINE 10-26-04 12:06am

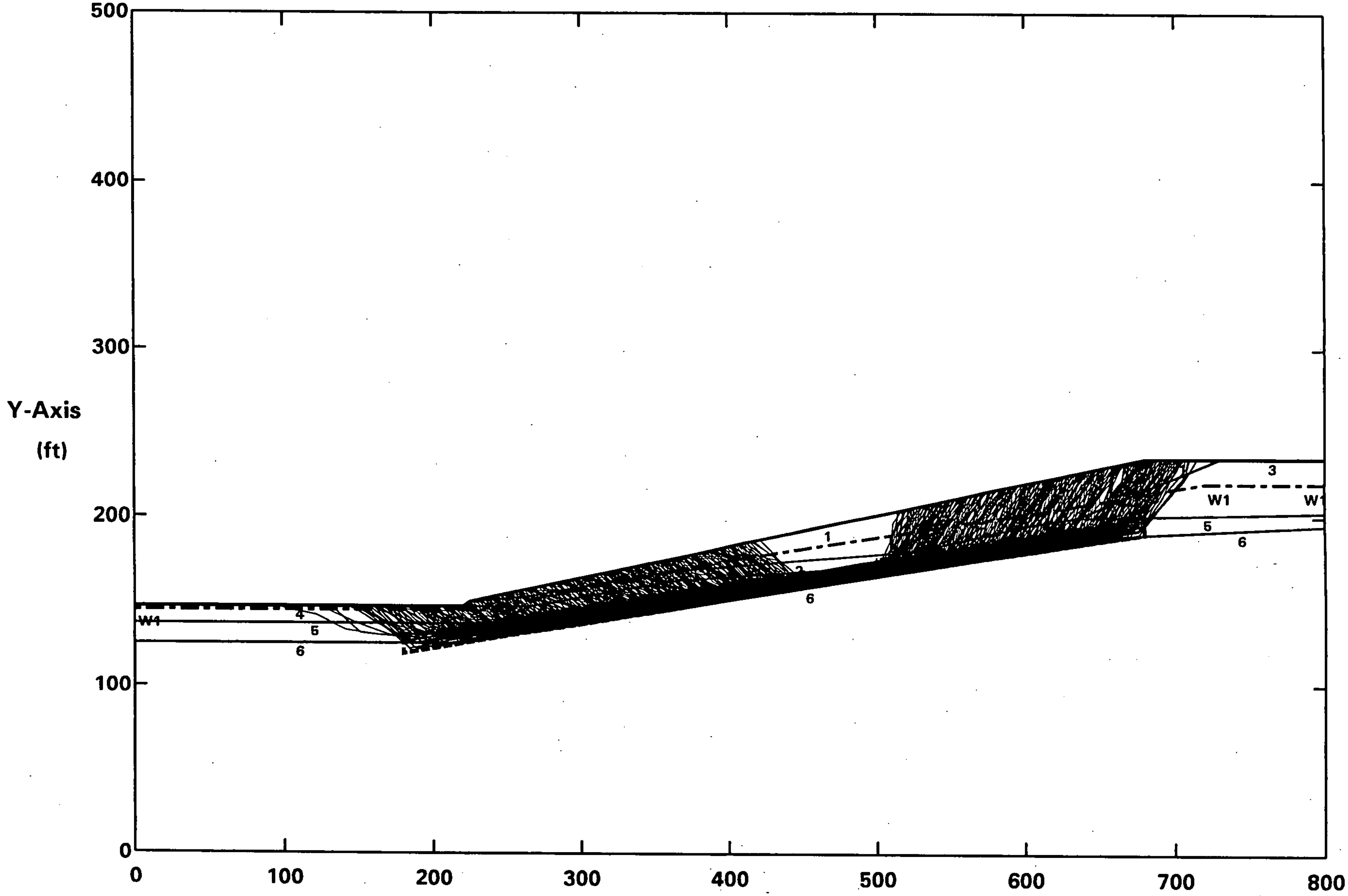
Label	Soil Type No.	Total Unit Wt. (pcf)	Saturated Unit Wt. (pcf)	Cohesion Intercept (psf)	Friction Angle (deg)	Pore Pressure Param.	Pressure Constant (psf)	Piez. Surface No.
WSTE/FIL	1	120	125	50	30	0	0	W1
Qc/SLIDE	2	120	125	0	15	0	0	W1
Qrf	3	120	125	200	30	0	0	W1
Qal	4	125	130	0	33	0	0	W1
WCS	5	120	125	0	15	0	0	W1
UCS	6	125	130	600	30	0	0	W1



PCSTABL5M/SI FSmin = 1.03 X-Axis (ft)
Factors Of Safety Calculated By The Modified Bishop Method

219

ROCKY FLATS OLF - M&E B 18% GRD - WCS = 15 deg - W/AVEGW - SLIDING BLOCK - 0.06g
All surfaces evaluated. C:BGAS06.PLT By: STAN KLINE 10-26-04 12:45am

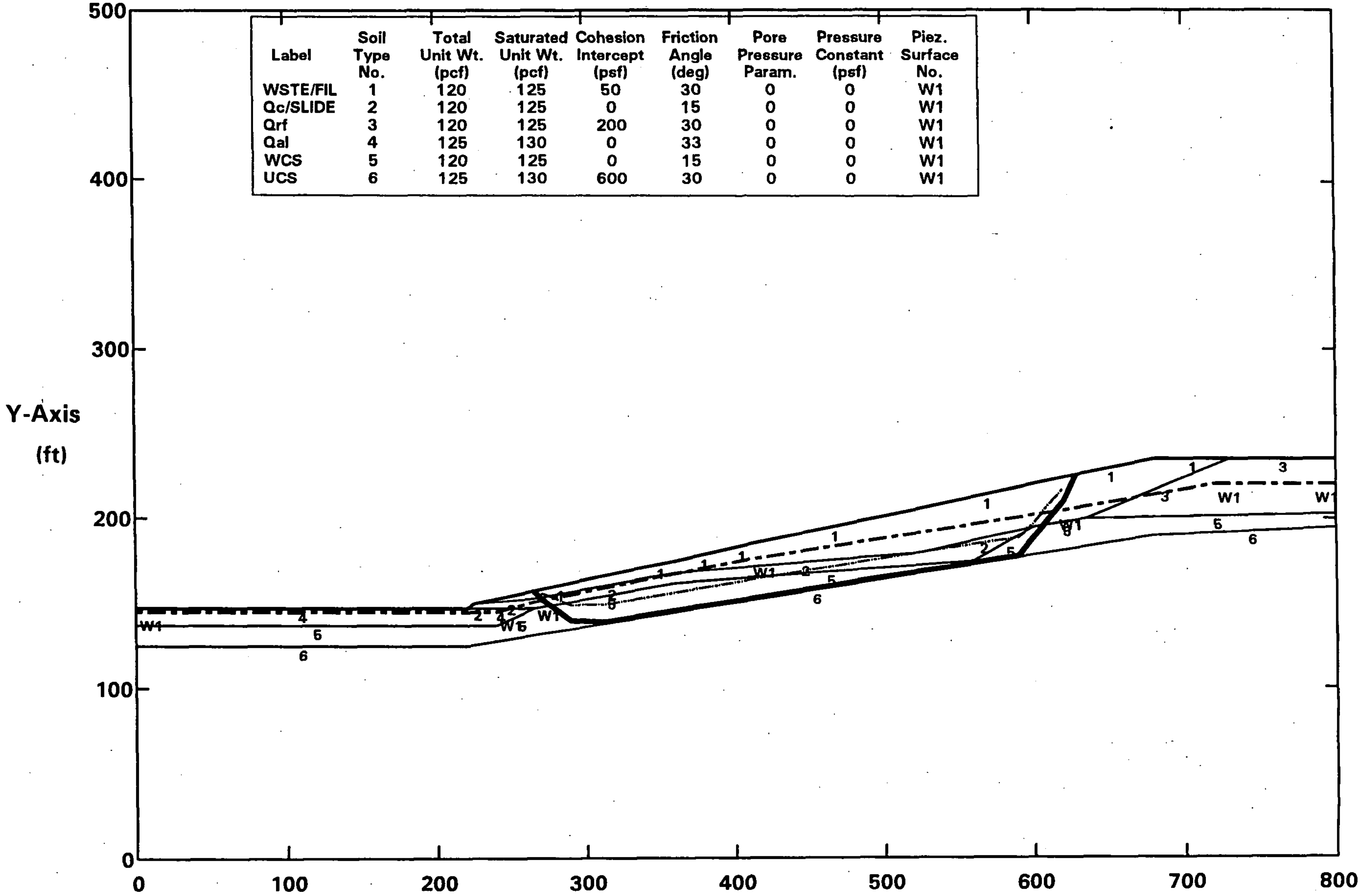


Factors Of Safety Calculated By The Modified Janbu Method

220

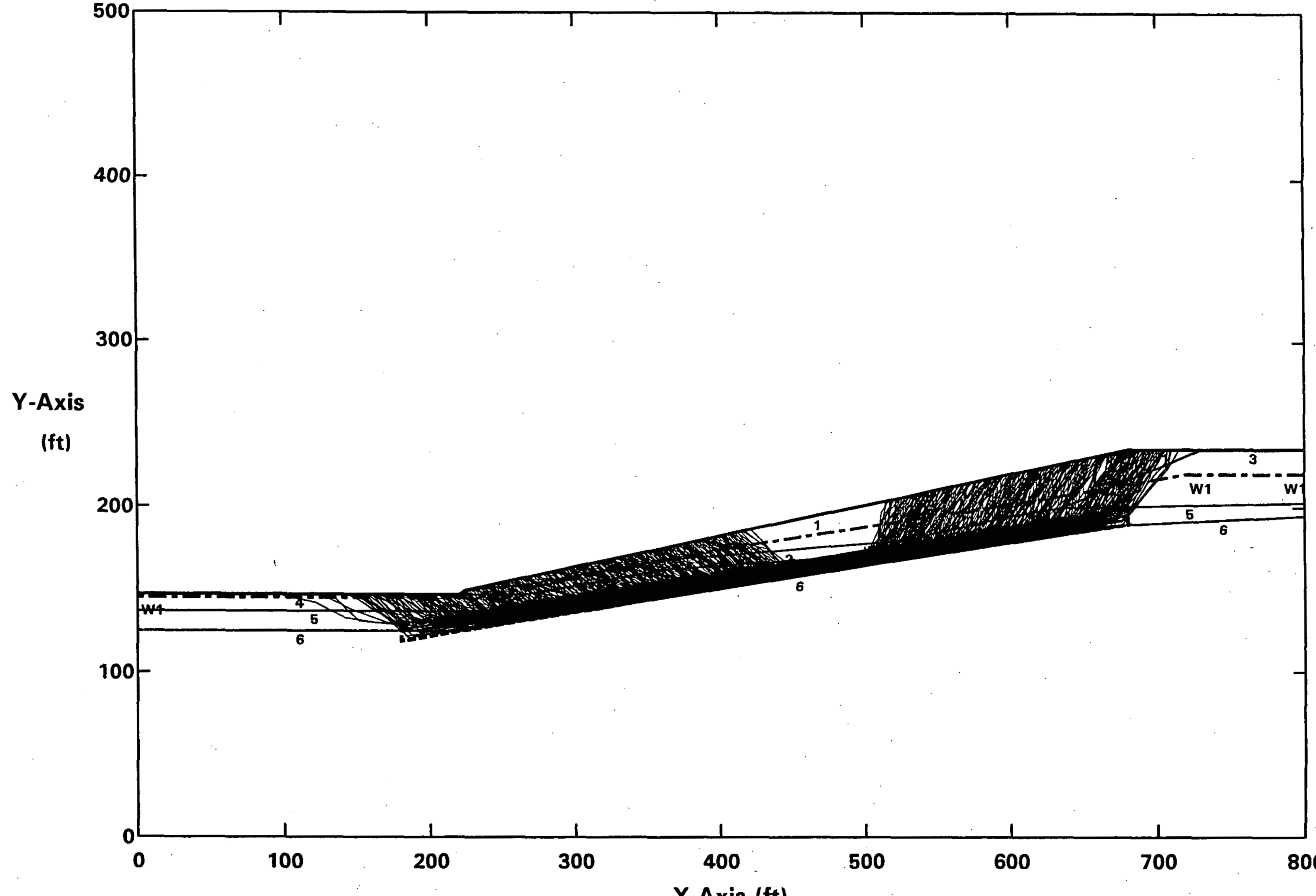
ROCKY FLATS OLF - M&E B 18% GRD - WCS = 15 deg - W/AVEGW - SLIDING BLOCK - 0.06g
Surface #1-BGAS06.OUT. C:BGAS06SP.PLT By: STAN KLINE 10-26-04 12:46am

Label	Soil Type No.	Total Unit Wt. (pcf)	Saturated Unit Wt. (pcf)	Cohesion Intercept (psf)	Friction Angle (deg)	Pore Pressure Param.	Pressure Constant (psf)	Piez. Surface No.
WSTE/FIL	1	120	125	50	30	0	0	W1
Qc/SLIDE	2	120	125	0	15	0	0	W1
Qrf	3	120	125	200	30	0	0	W1
Qal	4	125	130	0	33	0	0	W1
WCS	5	120	125	0	15	0	0	W1
UCS	6	125	130	600	30	0	0	W1



PCSTABL5M/SI FS = 0.88 Theta = 7.96 X-Axis (ft)
Factors Of Safety Calculated By Spencer`s Method of Slices

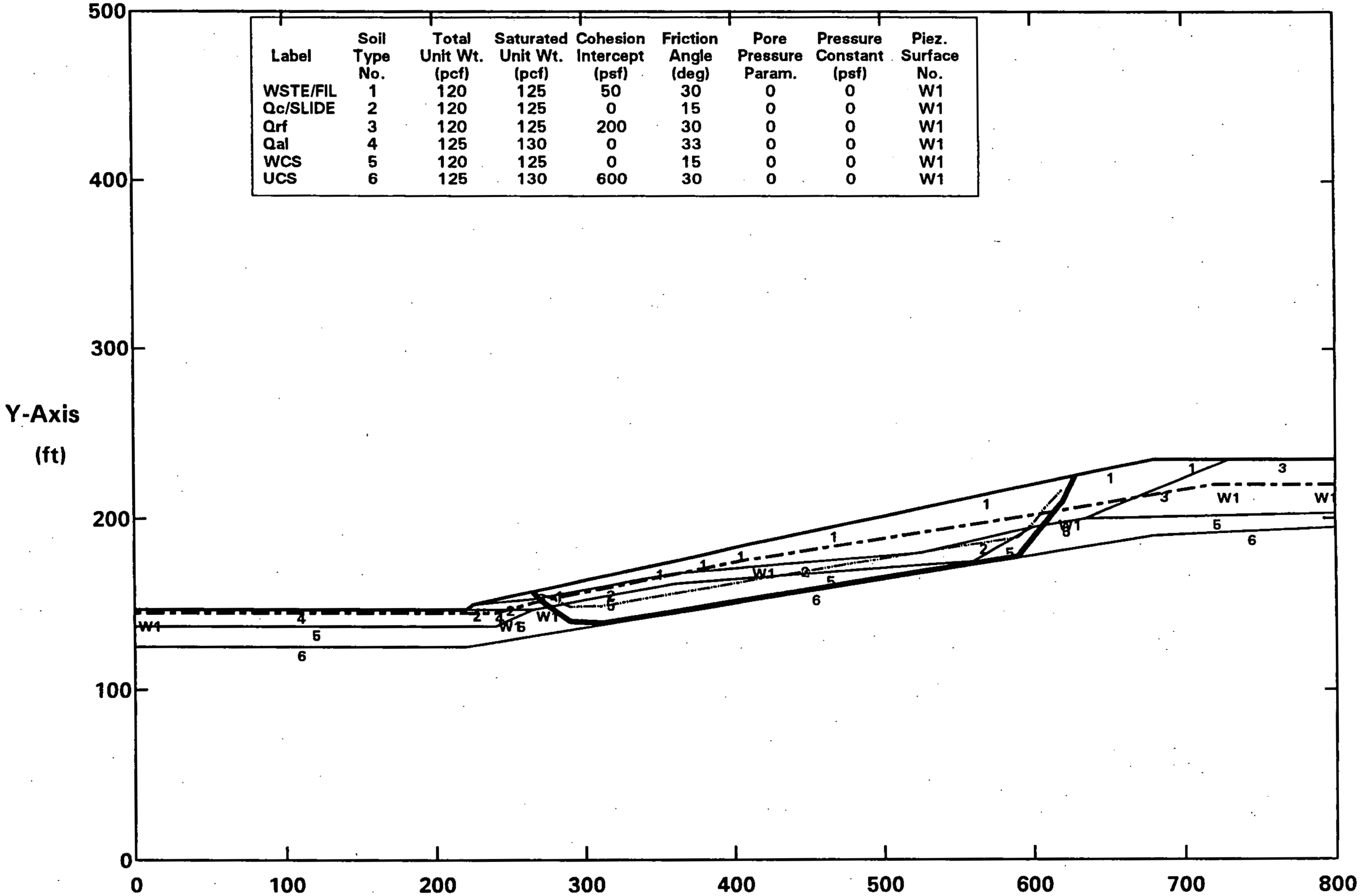
ROCKY FLATS OLF - M&E B 18% GRD - WCS = 15 deg - W/AVEGW - SLIDING BLOCK - 0.03g
All surfaces evaluated. C:BGAS03.PLT By: STAN KLINE 10-26-04 12:43am



Factors Of Safety Calculated By The Modified Janbu Method

222

ROCKY FLATS OLF - M&E B 18% GRD - WCS = 15 deg - W/AVEGW - SLIDING BLOCK - 0.03g
Surface #1-BGAS03.OUT. C:BGAS03SP.PLT By: STAN KLINE 10-26-04 12:44am



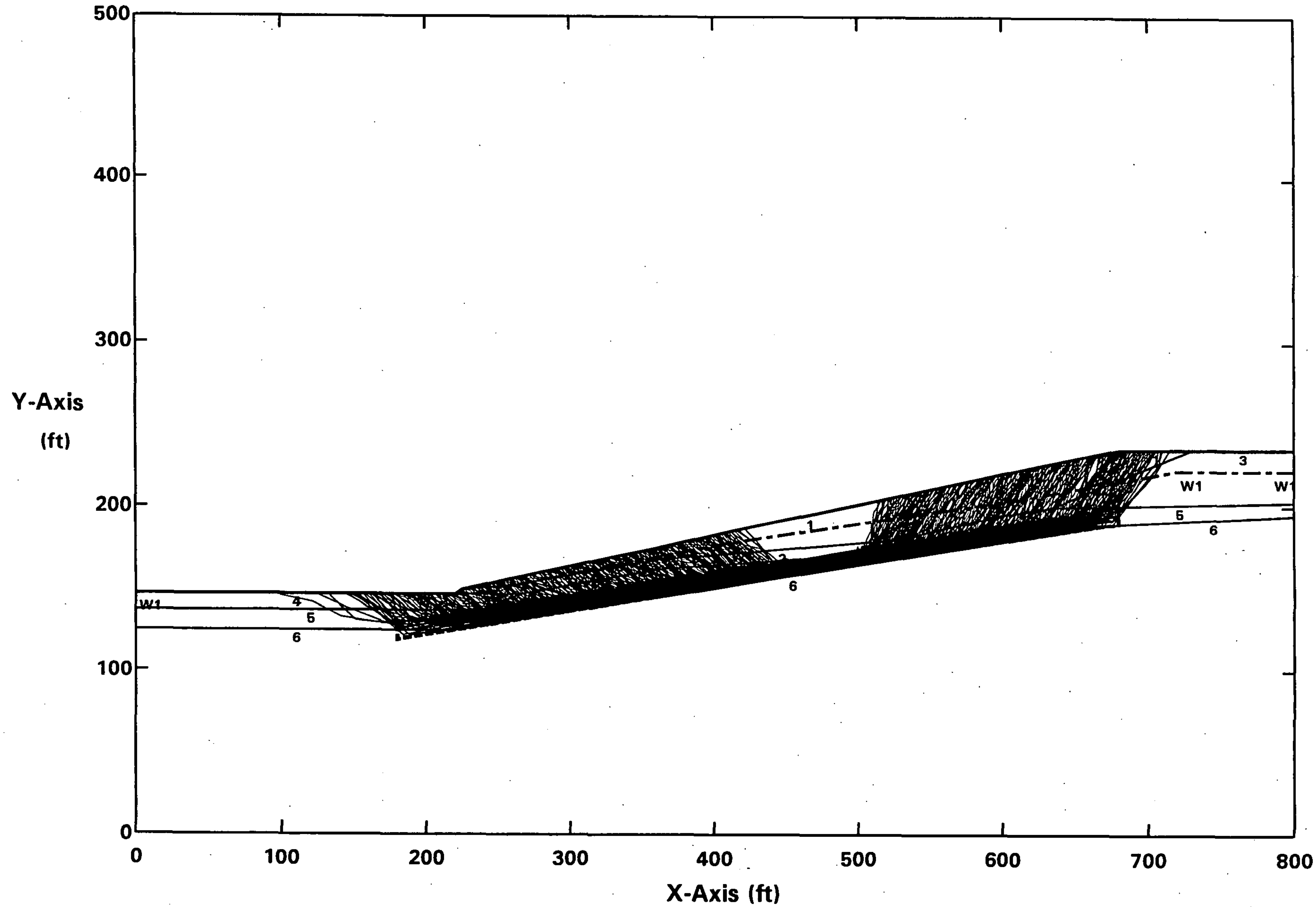
Label	Soil Type No.	Total Unit Wt. (pcf)	Saturated Unit Wt. (pcf)	Cohesion Intercept (psf)	Friction Angle (deg)	Pore Pressure Param.	Pressure Constant (psf)	Piez. Surface No.
WSTE/FIL	1	120	125	50	30	0	0	W1
Qc/SLIDE	2	120	125	0	15	0	0	W1
Qrf	3	120	125	200	30	0	0	W1
Qal	4	125	130	0	33	0	0	W1
WCS	5	120	125	0	15	0	0	W1
UCS	6	125	130	600	30	0	0	W1

PCSTABL5M/SI FS = 1.02 Theta = 8.26 X-Axis (ft)
Factors Of Safety Calculated By Spencer`s Method of Slices

222

ROCKY FLATS OLF - M&E B 18% GRD - WCS = 15 deg - W/HIGHGW - SLIDING BLOCK - 0.06g

All surfaces evaluated. C:BGHS06.PLT By: STAN KLINE 10-24-04 6:05pm

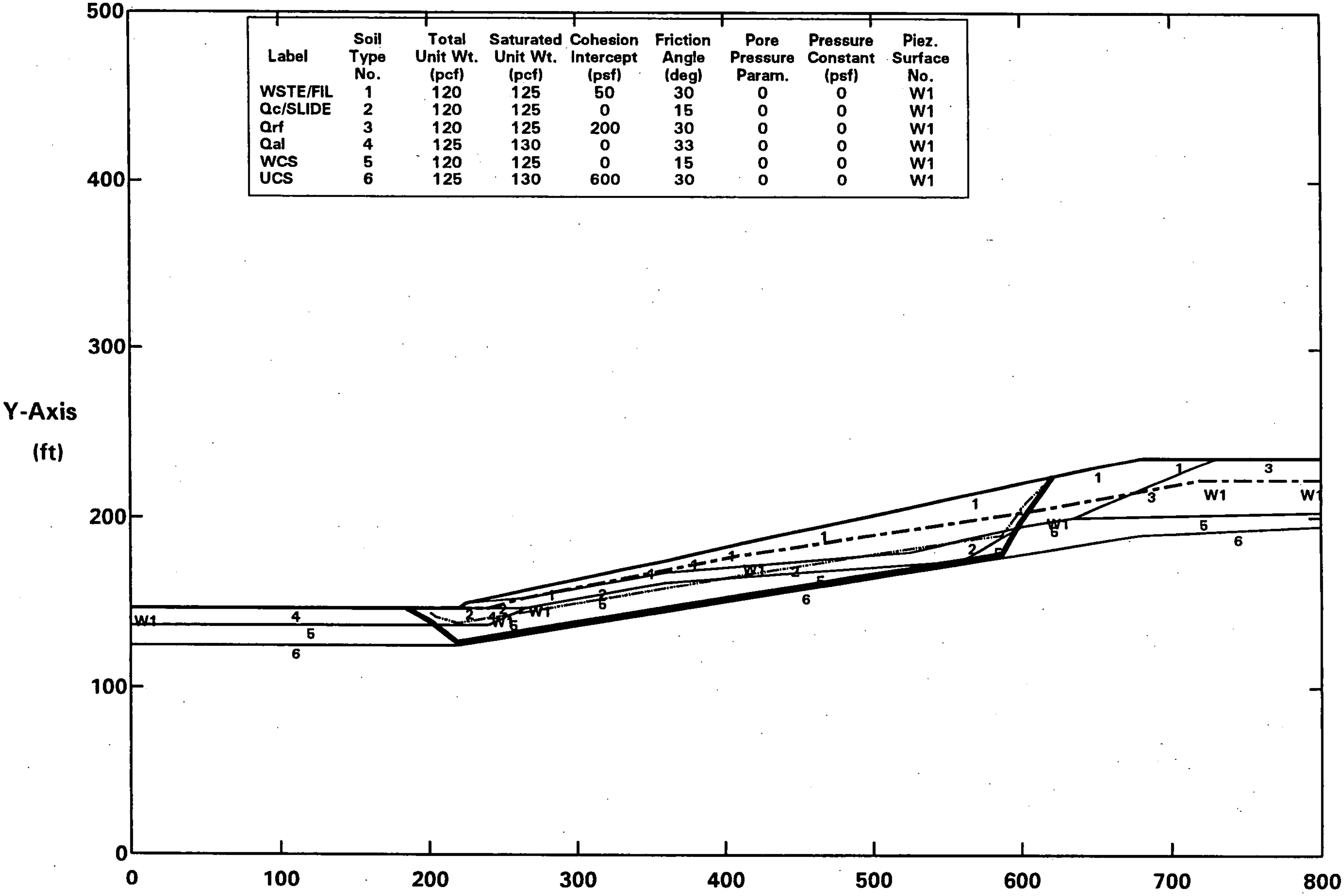


Factors Of Safety Calculated By The Modified Janbu Method

224

ROCKY FLATS OLF - M&E B 18% GRD - WCS=15 deg - W/HIGHGW - SLIDING BLOCK - 0.06g
Surface #1-BGHS06.OUT. C:BGHS06SP.PLT By: STAN KLINE 10-24-04 6:07pm

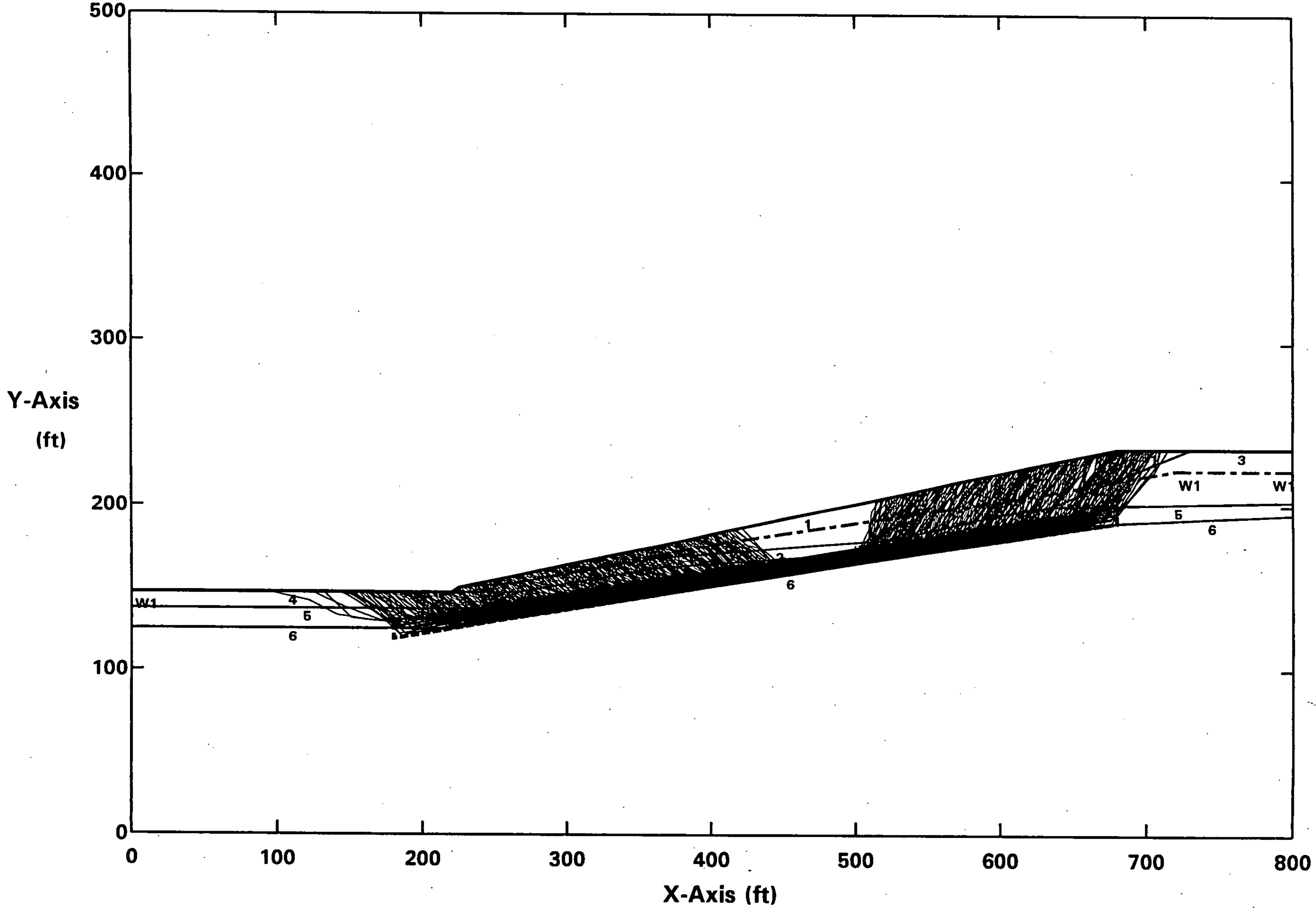
Label	Soil Type No.	Total Unit Wt. (pcf)	Saturated Unit Wt. (pcf)	Cohesion Intercept (psf)	Friction Angle (deg)	Pore Pressure Param.	Pressure Constant (psf)	Piez. Surface No.
WSTE/FIL	1	120	125	50	30	0	0	W1
Qc/SLIDE	2	120	125	0	15	0	0	W1
Qrf	3	120	125	200	30	0	0	W1
Qal	4	125	130	0	33	0	0	W1
WCS	5	120	125	0	15	0	0	W1
UCS	6	125	130	600	30	0	0	W1



PCSTABL5M/SI FS=0.85 Theta=7.86 X-Axis (ft)
Factors Of Safety Calculated By Spencer`s Method of Slices

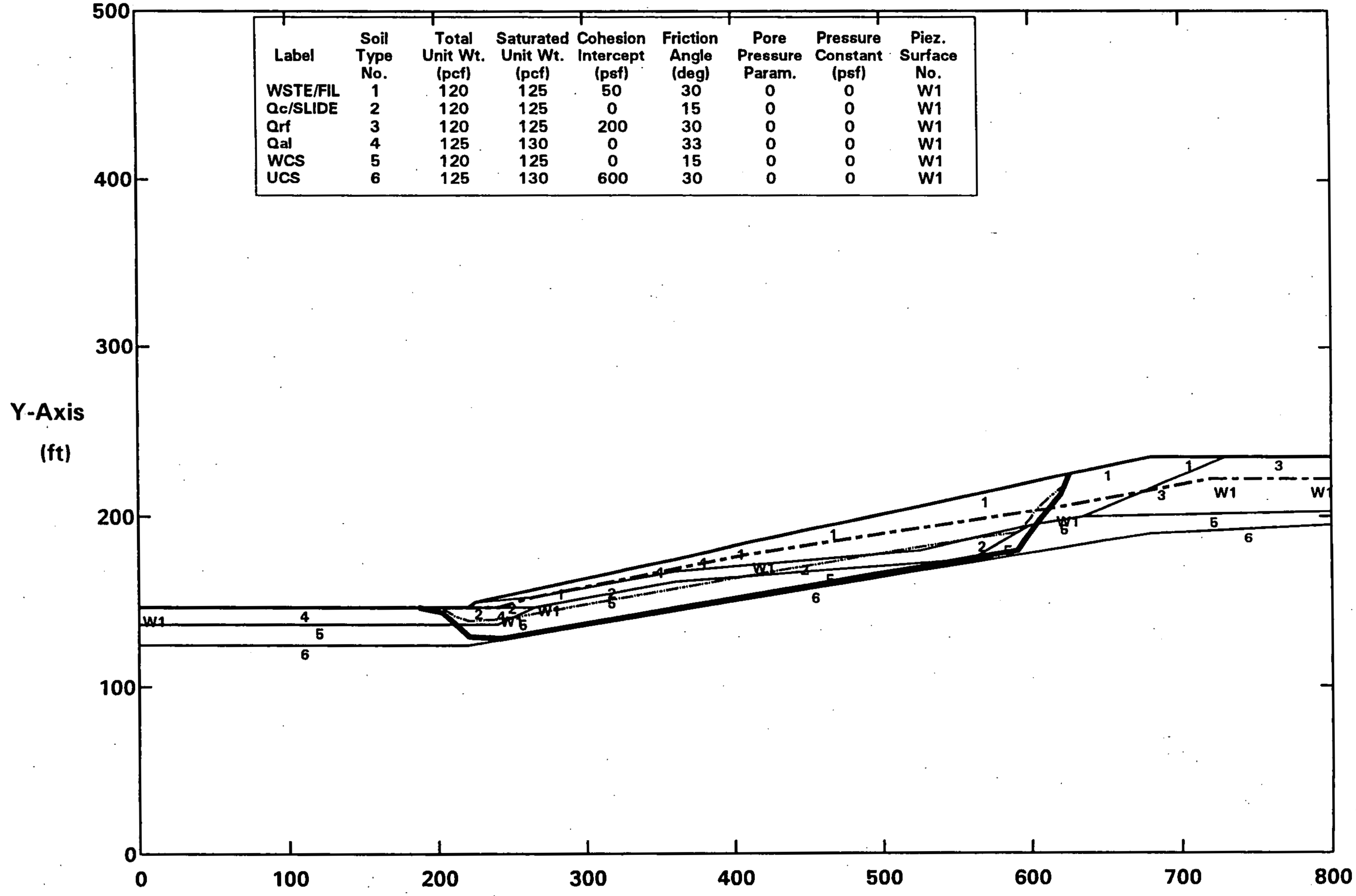
225

ROCKY FLATS OLF - M&E B 18% GRD - WCS = 15 deg - W/HIGHGW - SLIDING BLOCK - 0.02g
All surfaces evaluated. C:BGHS02.PLT By: STAN KLINE 10-24-04 6:02pm



Factors Of Safety Calculated By The Modified Janbu Method

ROCKY FLATS OLF - M&E B 18% GRD - WCS=15 deg - W/HIGHGW - SLIDING BLOCK - 0.02g
Surface #1-BGHS02.OUT. C:BGHS02SP.PLT By: STAN KLINE 10-24-04 6:04pm



Label	Soil Type No.	Total Unit Wt. (pcf)	Saturated Unit Wt. (pcf)	Cohesion Intercept (psf)	Friction Angle (deg)	Pore Pressure Param.	Pressure Constant (psf)	Piez. Surface No.
WSTE/FIL	1	120	125	50	30	0	0	W1
Qc/SLIDE	2	120	125	0	15	0	0	W1
Qrf	3	120	125	200	30	0	0	W1
Qal	4	125	130	0	33	0	0	W1
WCS	5	120	125	0	15	0	0	W1
UCS	6	125	130	600	30	0	0	W1

PCSTABL5M/SI FS=1.03 Theta=8.19 X-Axis (ft)
Factors Of Safety Calculated By Spencer`s Method of Slices

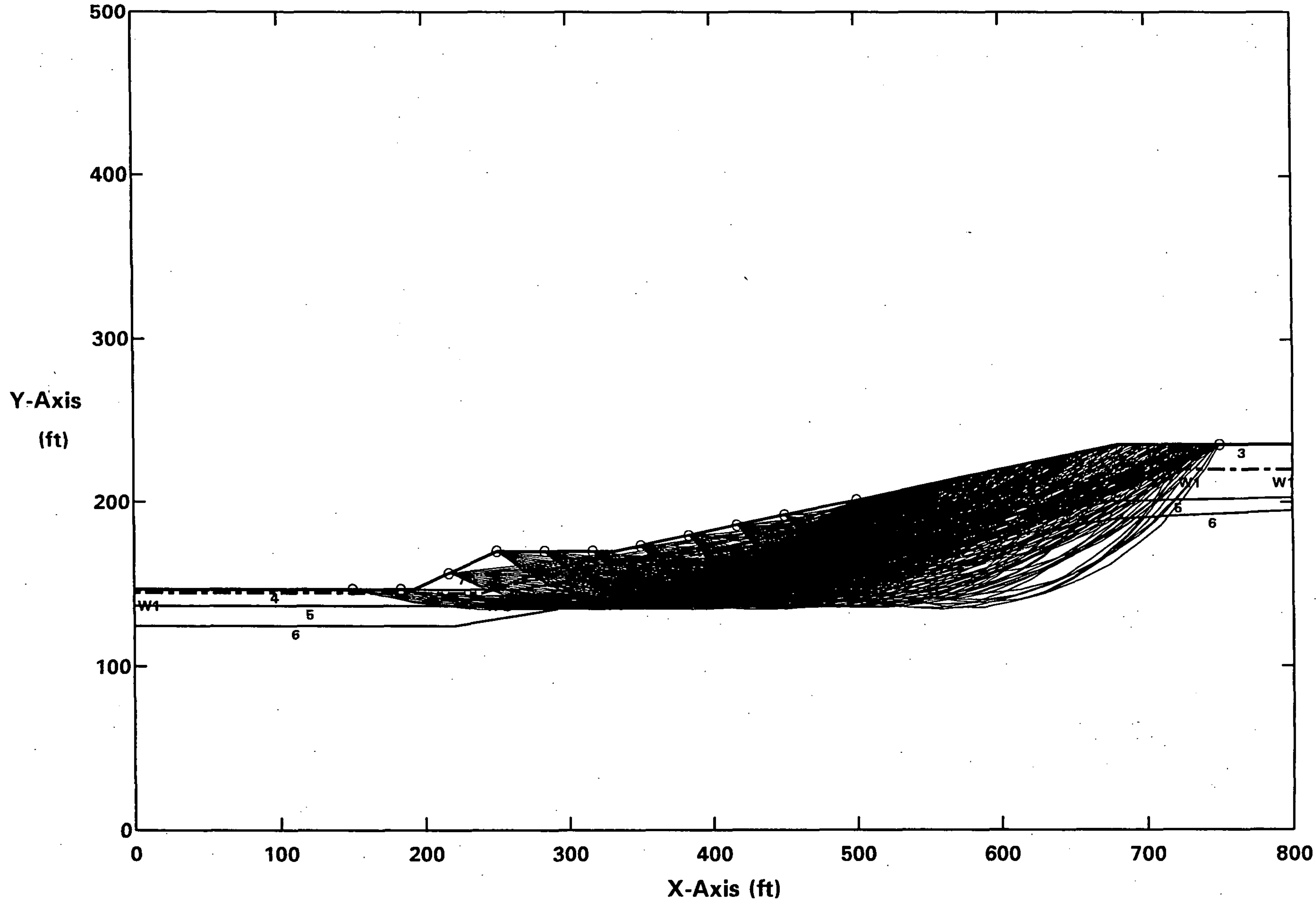
18% REGRADE WITH BUTTRESS CONDITION

227

228

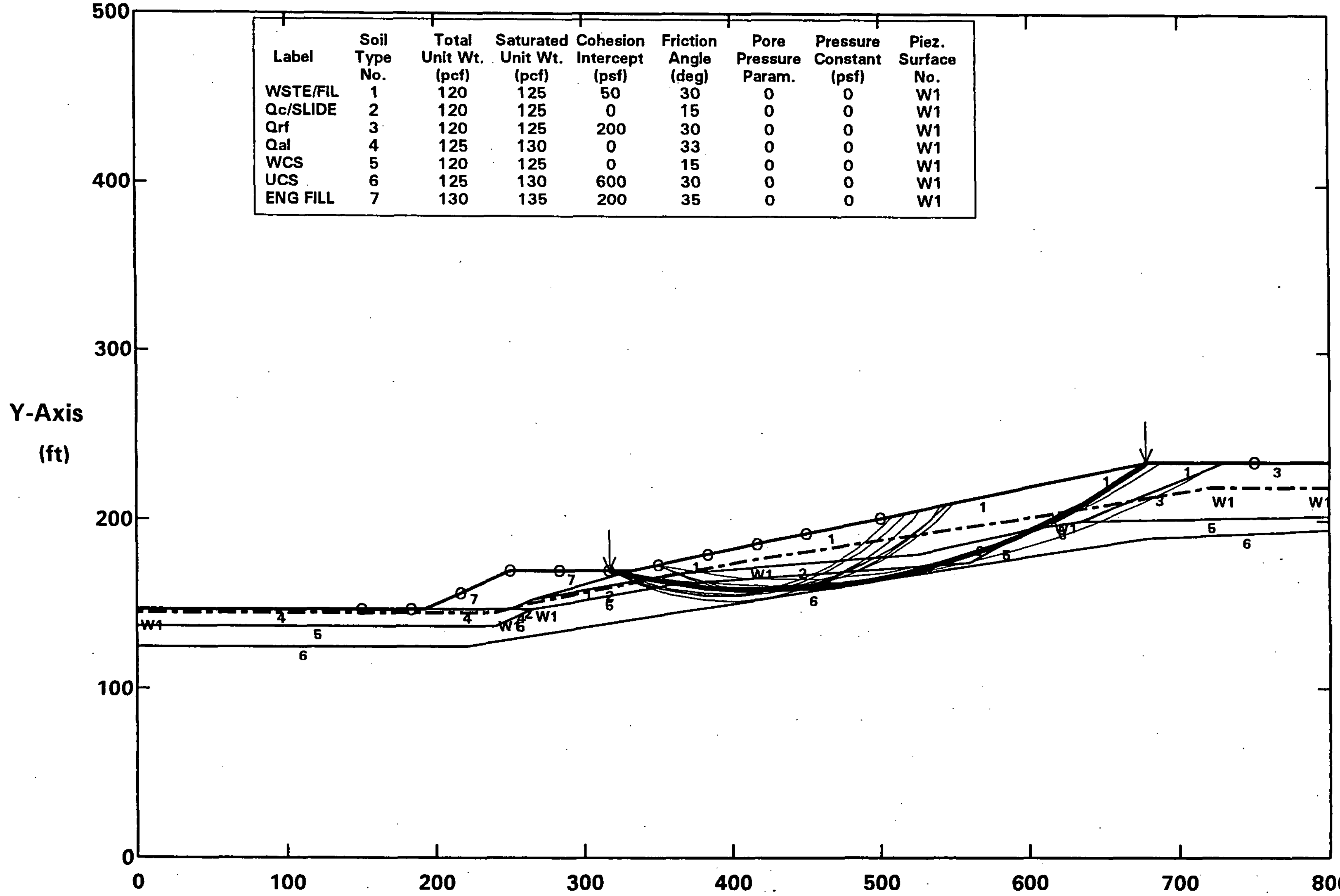
ROCKY FLATS OLF - M&E B 18%W/BM - WCS = 15 deg - W/AVEGW - CIRCULAR - 0.06g

All surfaces evaluated. C:BBAC06.PLT By: STAN KLINE 10-26-04 12:03am



Factors Of Safety Calculated By The Modified Bishop Method

ROCKY FLATS OLF - M&E B 18%W/BM - WCS=15 deg - W/AVEGW - CIRCULAR - 0.06g
Ten Most Critical. C:BBAC06.PLT By: STAN KLINE 10-26-04 12:03am

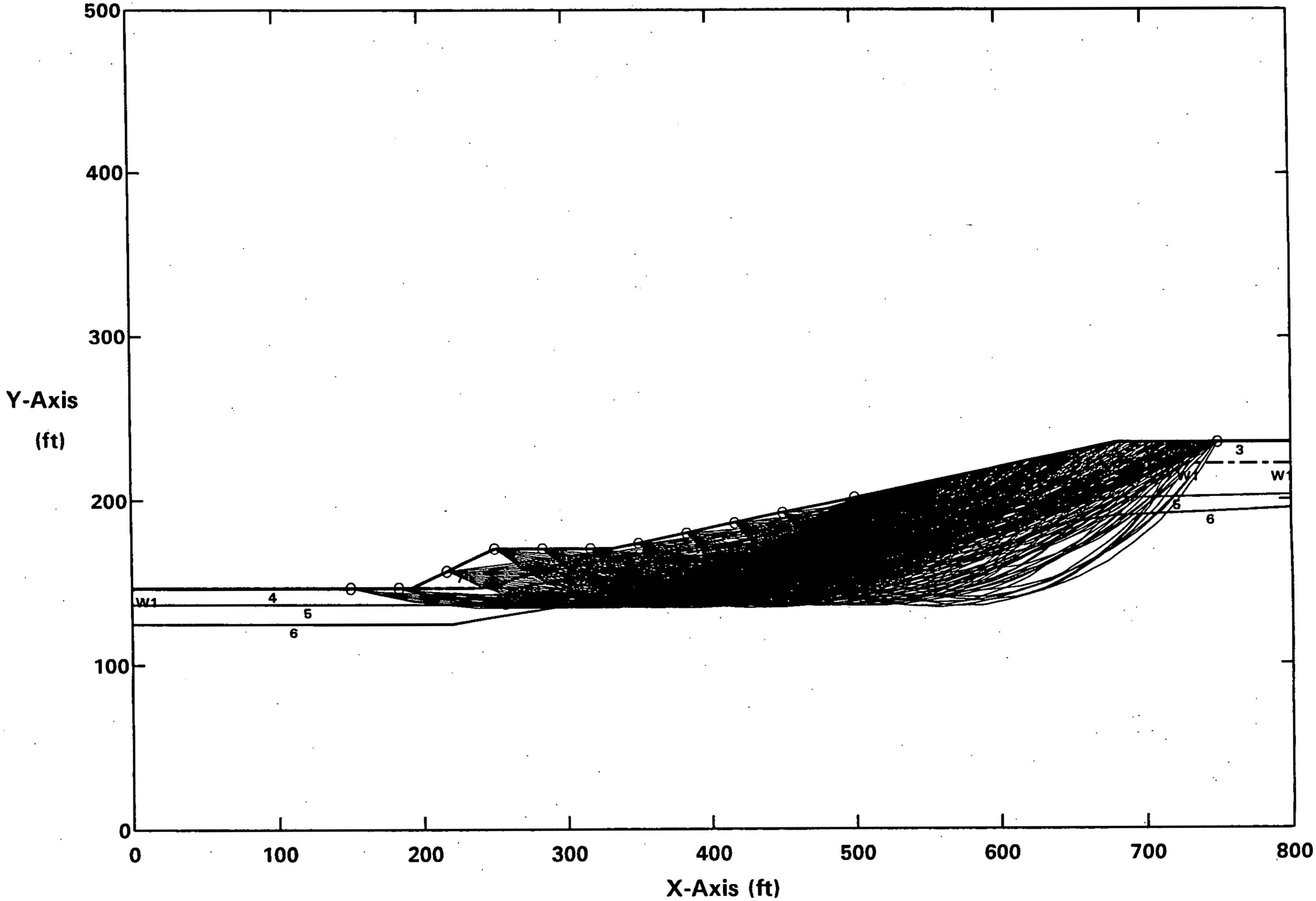


Label	Soil Type No.	Total Unit Wt. (pcf)	Saturated Unit Wt. (pcf)	Cohesion Intercept (psf)	Friction Angle (deg)	Pore Pressure Param.	Pressure Constant (psf)	Piez. Surface No.
WSTE/FIL	1	120	125	50	30	0	0	W1
Qc/SLIDE	2	120	125	0	15	0	0	W1
Qrf	3	120	125	200	30	0	0	W1
Qal	4	125	130	0	33	0	0	W1
WCS	5	120	125	0	15	0	0	W1
UCS	6	125	130	600	30	0	0	W1
ENG FILL	7	130	135	200	35	0	0	W1

PCSTABL5M/SI FSmin=1.01 X-Axis (ft)
Factors Of Safety Calculated By The Modified Bishop Method

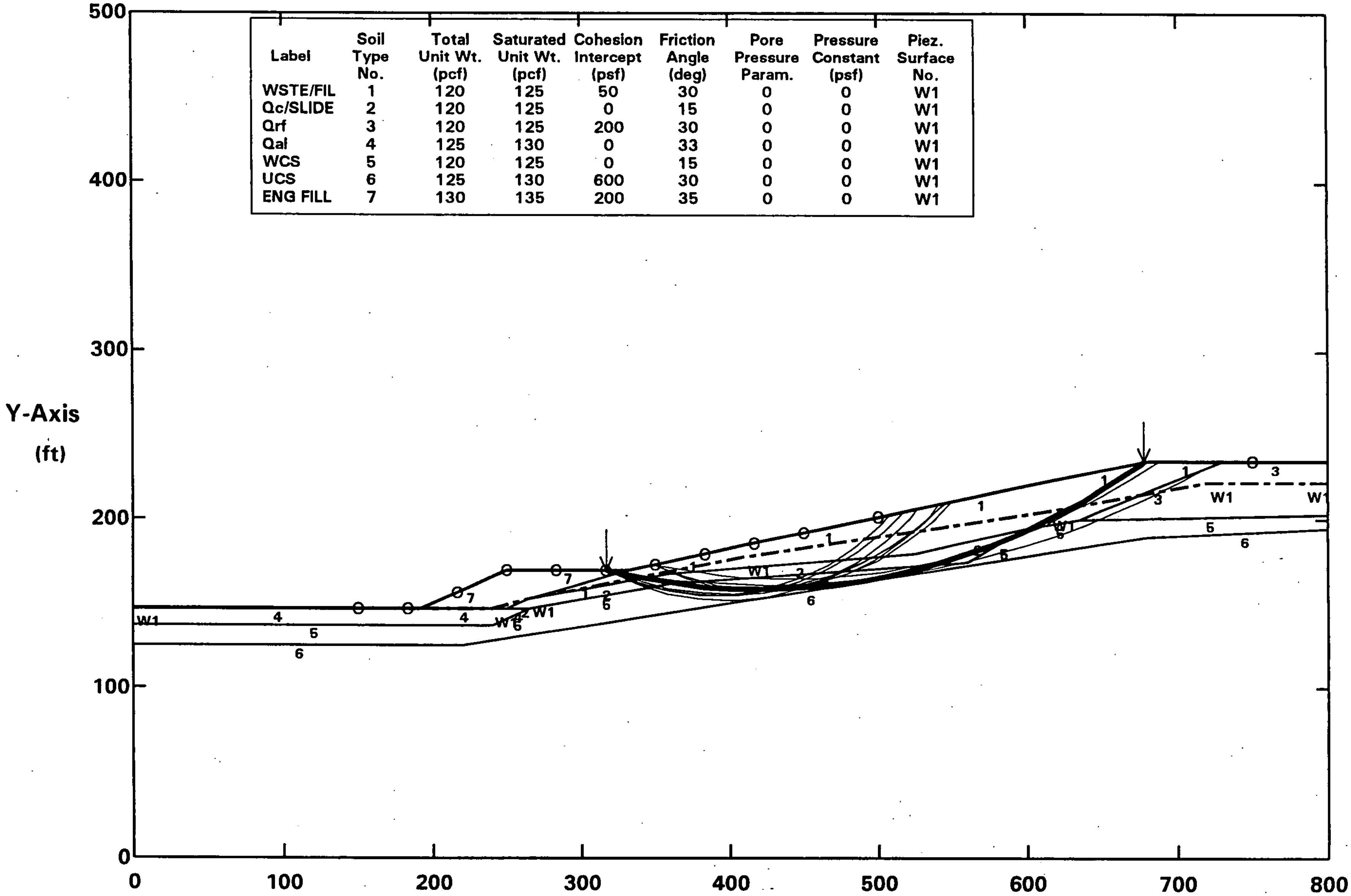
220

ROCKY FLATS OLF - M&E B 18%W/BM - WCS = 15 deg - W/HIGHGW - CIRCULAR - 0.06g
All surfaces evaluated. C:BBHC06.PLT By: STAN KLINE 10-26-04 12:09am



Factors Of Safety Calculated By The Modified Bishop Method

ROCKY FLATS OLF - M&E B 18%W/BM - WCS=15 deg - W/HIGHGW - CIRCULAR - 0.06g
Ten Most Critical. C:BBHC06.PLT By: STAN KLINE 10-26-04 12:09am

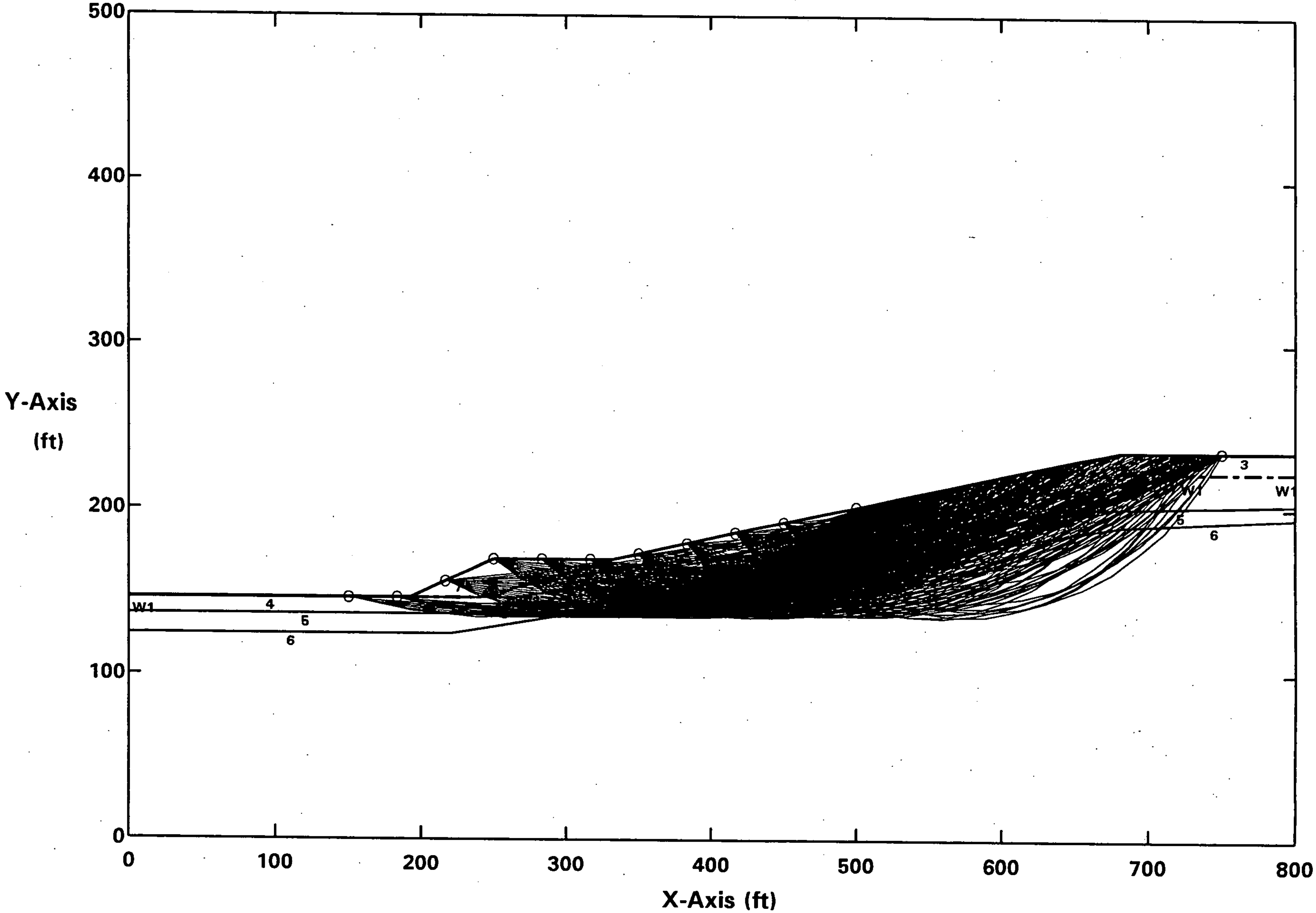


Label	Soil Type No.	Total Unit Wt. (pcf)	Saturated Unit Wt. (pcf)	Cohesion Intercept (psf)	Friction Angle (deg)	Pore Pressure Param.	Pressure Constant (psf)	Piez. Surface No.
WSTE/FIL	1	120	125	50	30	0	0	W1
Qc/SLIDE	2	120	125	0	15	0	0	W1
Qrf	3	120	125	200	30	0	0	W1
Qal	4	125	130	0	33	0	0	W1
WCS	5	120	125	0	15	0	0	W1
UCS	6	125	130	600	30	0	0	W1
ENG FILL	7	130	135	200	35	0	0	W1

PCSTABL5M/SI FSmin=0.98 X-Axis (ft)
Factors Of Safety Calculated By The Modified Bishop Method

232

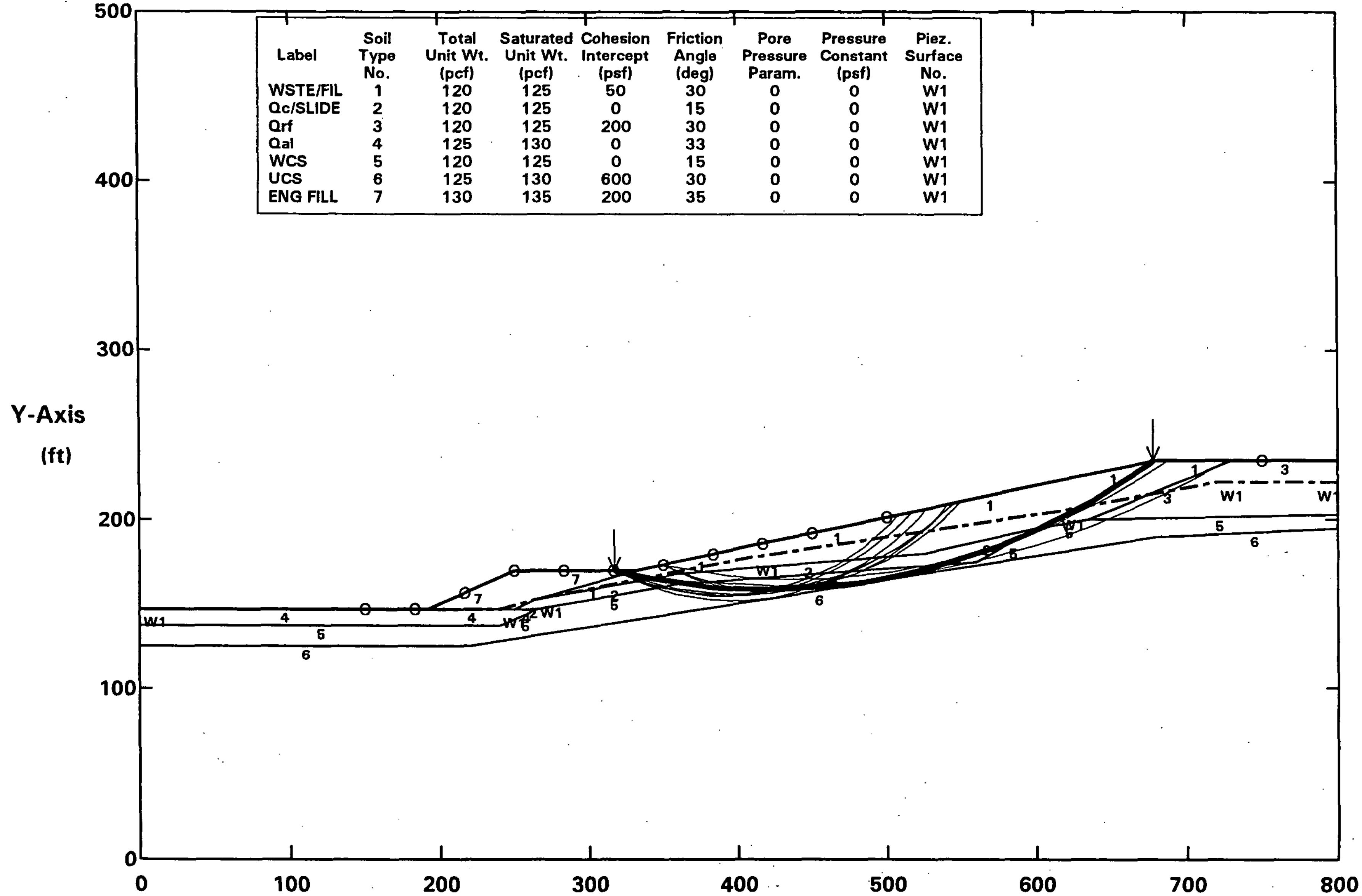
ROCKY FLATS OLF - M&E B 18%W/BM - WCS = 15 deg - W/HIGHGW - CIRCULAR - 0.05g
All surfaces evaluated. C:BBHC05.PLT By: STAN KLINE 10-26-04 12:07am



Factors Of Safety Calculated By The Modified Bishop Method

ROCKY FLATS OLF - M&E B 18%W/BM - WCS=15 deg - W/HIGHGW - CIRCULAR - 0.05g
Ten Most Critical. C:BBHC05.PLT By: STAN KLINE 10-26-04 12:07am

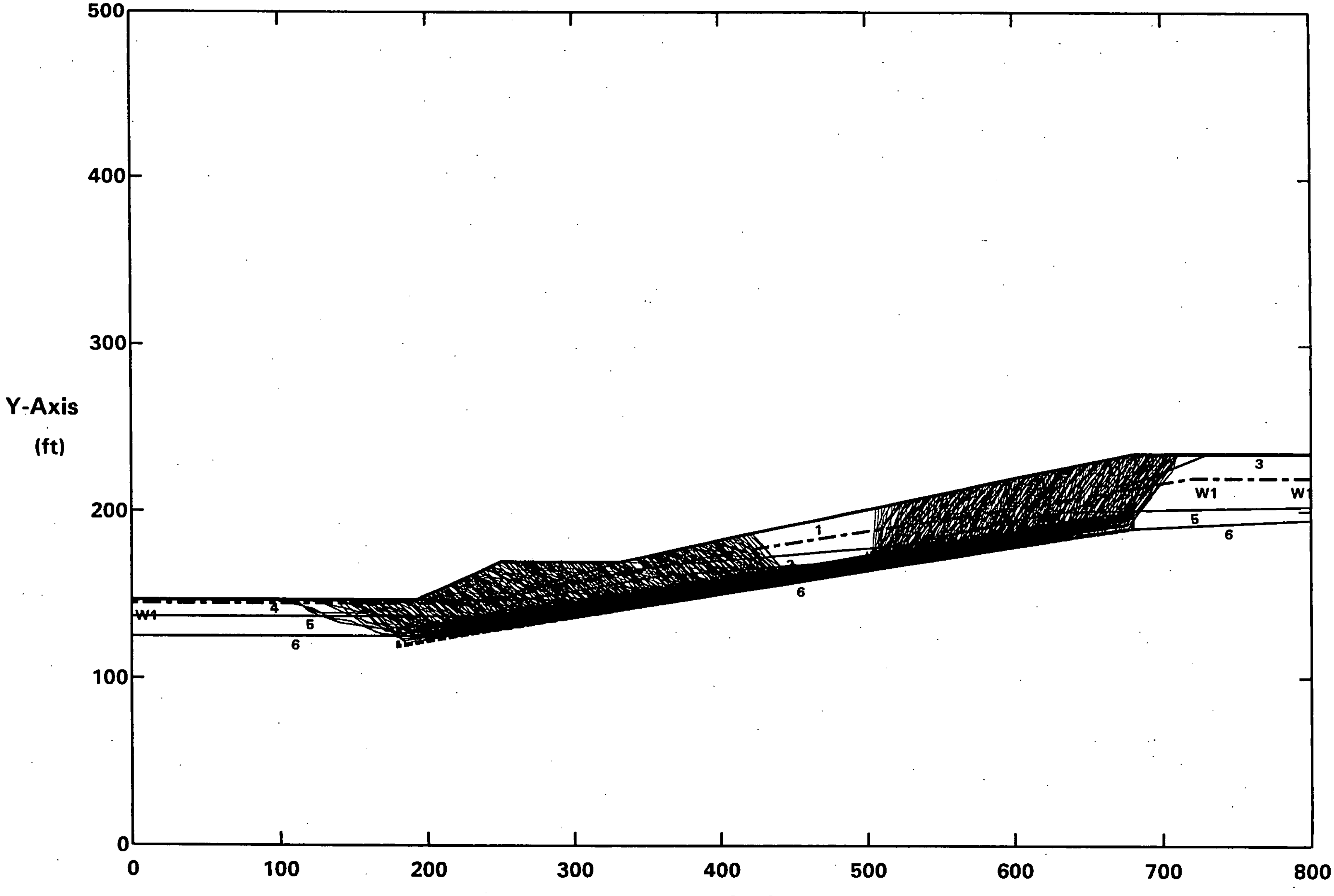
Label	Soil Type No.	Total Unit Wt. (pcf)	Saturated Unit Wt. (pcf)	Cohesion Intercept (psf)	Friction Angle (deg)	Pore Pressure Param.	Pressure Constant (psf)	Piez. Surface No.
WSTE/FIL	1	120	125	50	30	0	0	W1
Qc/SLIDE	2	120	125	0	15	0	0	W1
Qrf	3	120	125	200	30	0	0	W1
Qal	4	125	130	0	33	0	0	W1
WCS	5	120	125	0	15	0	0	W1
UCS	6	125	130	600	30	0	0	W1
ENG FILL	7	130	135	200	35	0	0	W1



PCSTABL5M/SI FSmin=1.02 X-Axis (ft)
Factors Of Safety Calculated By The Modified Bishop Method

234

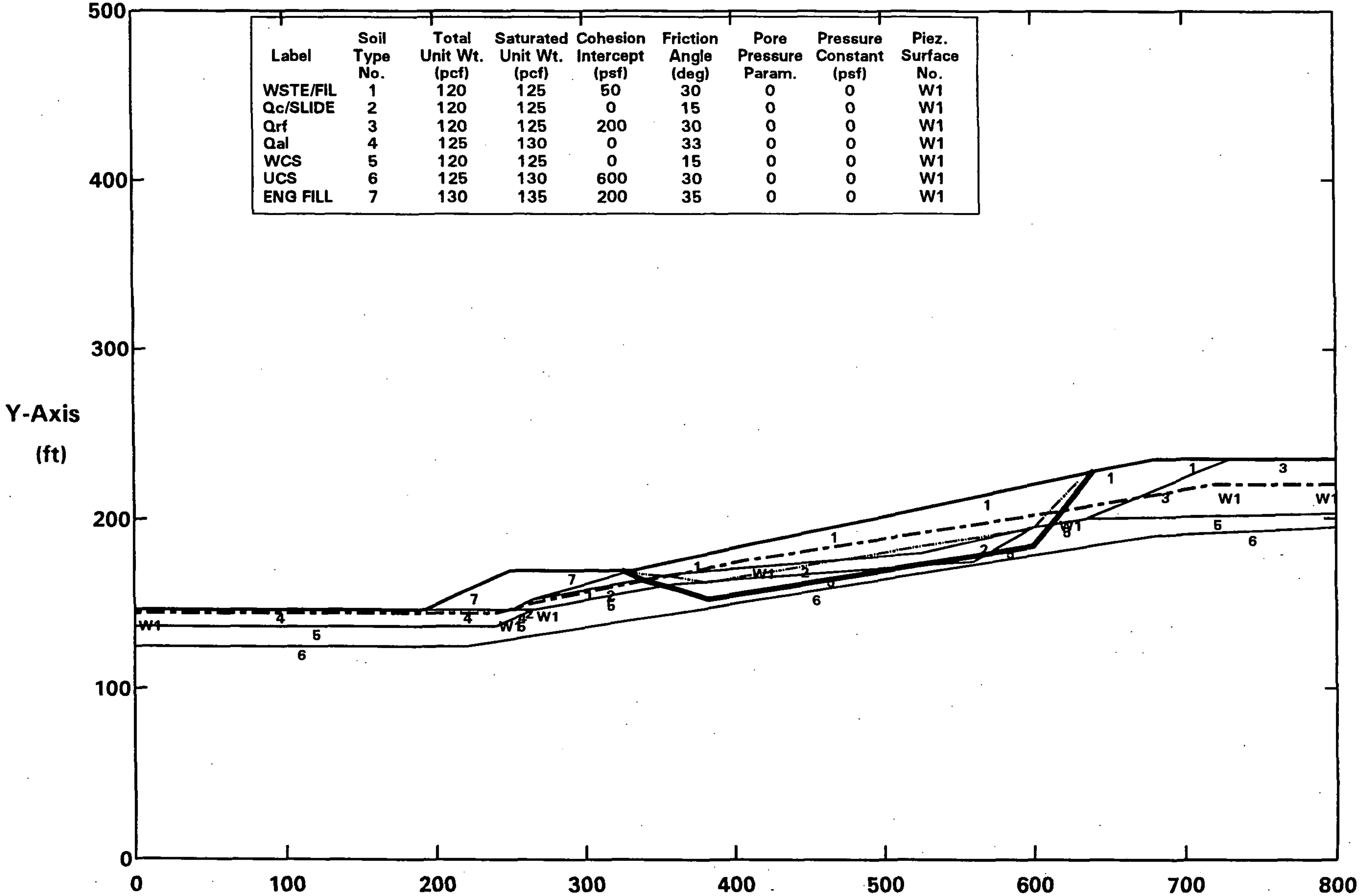
ROCKY FLATS OLF - M&E B 18%W/BM - WCS = 15 deg - W/AVEGW - SLIDING BLOCK - 0.06g
All surfaces evaluated. C:BBAS06.PLT By: STAN KLINE 10-26-04 12:48am



Factors Of Safety Calculated By The Modified Janbu Method

225

ROCKY FLATS OLF - M&E B 18%W/BM - WCS=15 deg - W/AVEGW - SLIDING BLOCK - 0.06g
Surface #1-BBAS06.OUT. C:BBAS06SP.PLT By: STAN KLINE 10-26-04 12:49am

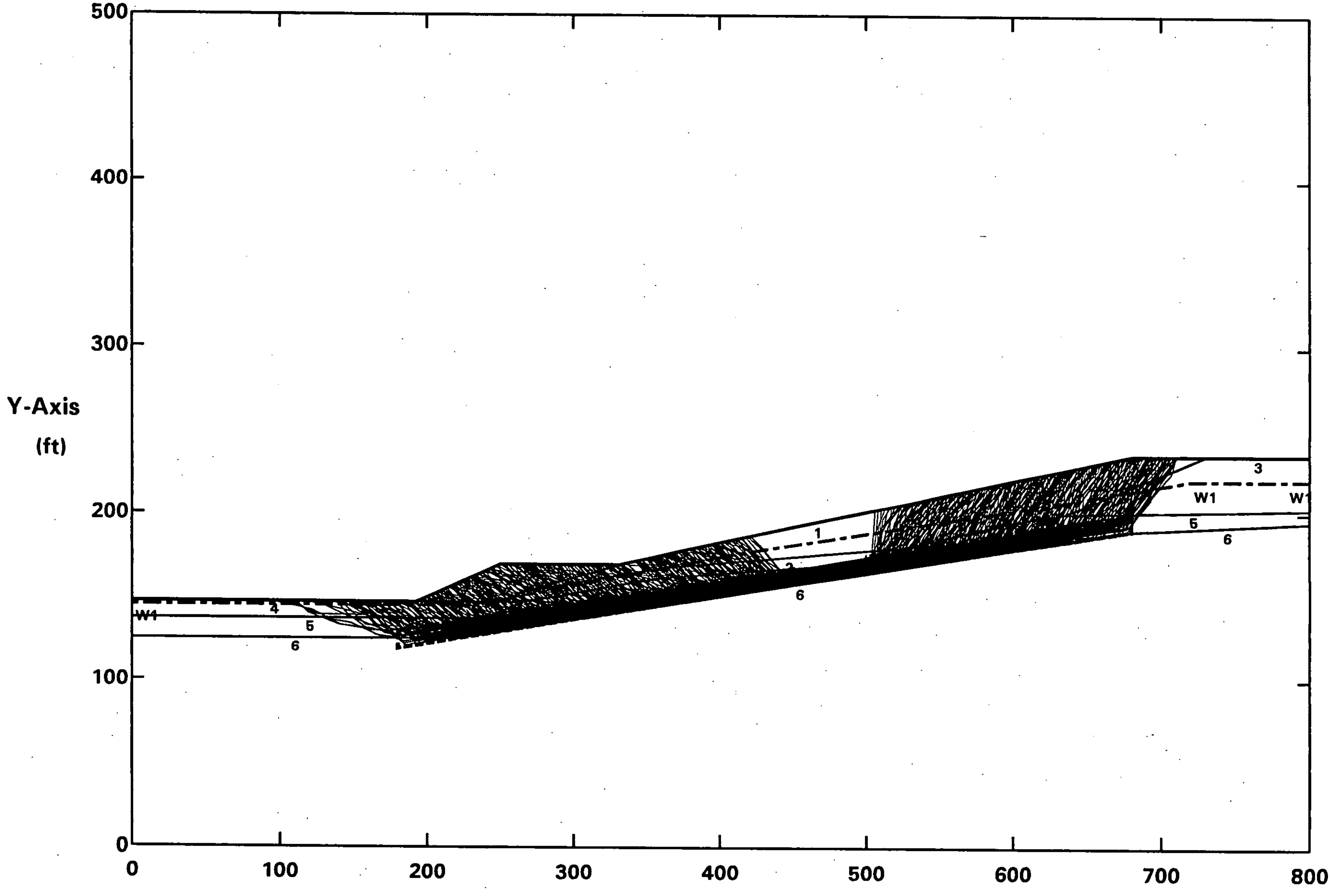


Label	Soil Type No.	Total Unit Wt. (pcf)	Saturated Unit Wt. (pcf)	Cohesion Intercept (psf)	Friction Angle (deg)	Pore Pressure Param.	Pressure Constant (psf)	Piez. Surface No.
WSTE/FIL	1	120	125	50	30	0	0	W1
Qc/SLIDE	2	120	125	0	15	0	0	W1
Qrf	3	120	125	200	30	0	0	W1
Qal	4	125	130	0	33	0	0	W1
WCS	5	120	125	0	15	0	0	W1
UCS	6	125	130	600	30	0	0	W1
ENG FILL	7	130	135	200	35	0	0	W1

PCSTABL5M/SI FS=0.95 Theta=7.75 X-Axis (ft)
Factors Of Safety Calculated By Spencer`s Method of Slices

236

ROCKY FLATS OLF - M&E B 18%W/BM - WCS = 15 deg - W/AVEGW - SLIDING BLOCK - 0.05g
All surfaces evaluated. C:BBAS05.PLT By: STAN KLINE 10-26-04 12:47am

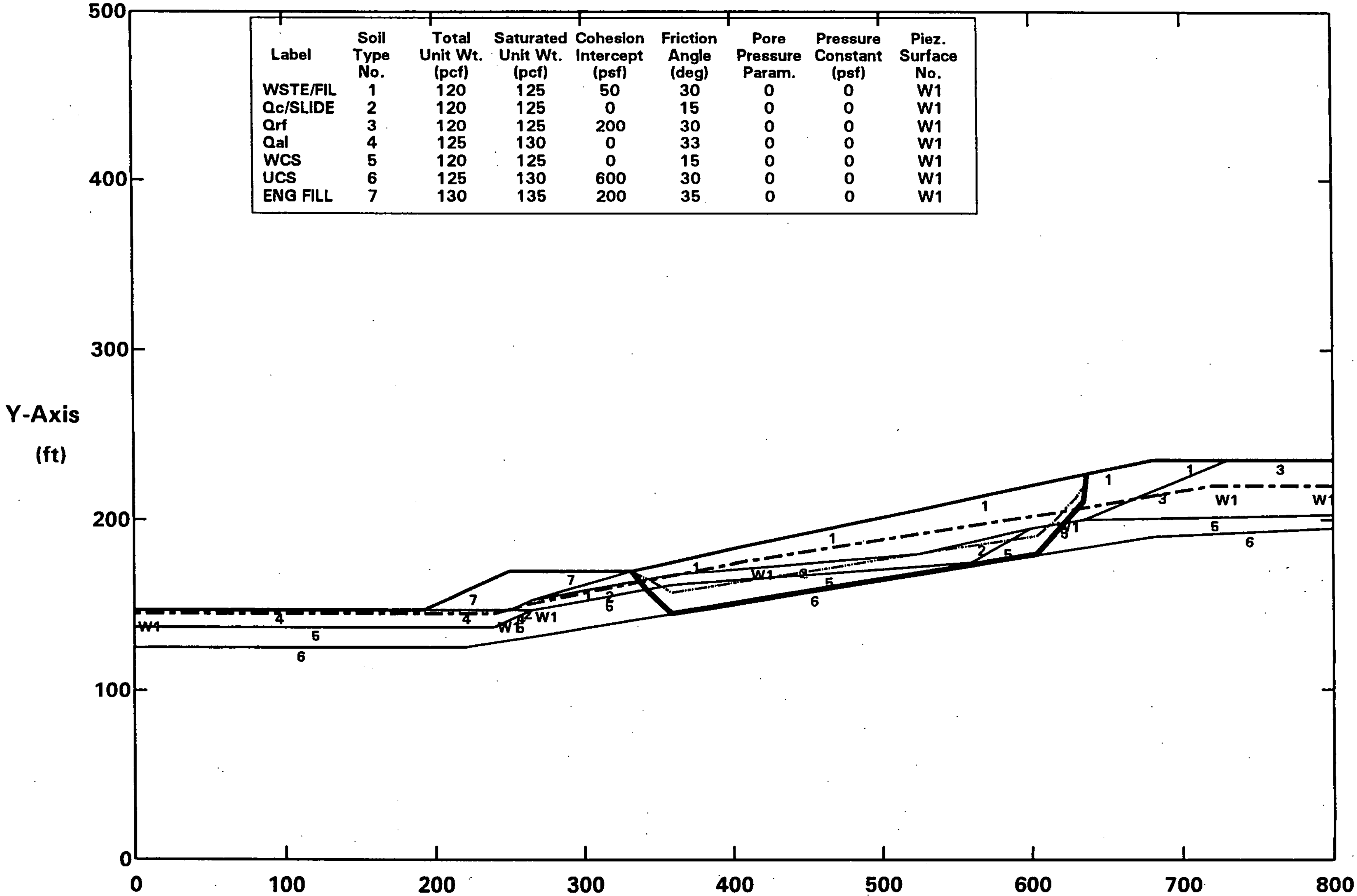


Factors Of Safety Calculated By The Modified Janbu Method

227

ROCKY FLATS OLF - M&E B 18%W/BM - WCS=15 deg - W/AVEGW - SLIDING BLOCK - 0.05g
Surface #1-BBAS05.OUT. C:BBAS05SP.PLT By: STAN KLINE 10-26-04 12:48am

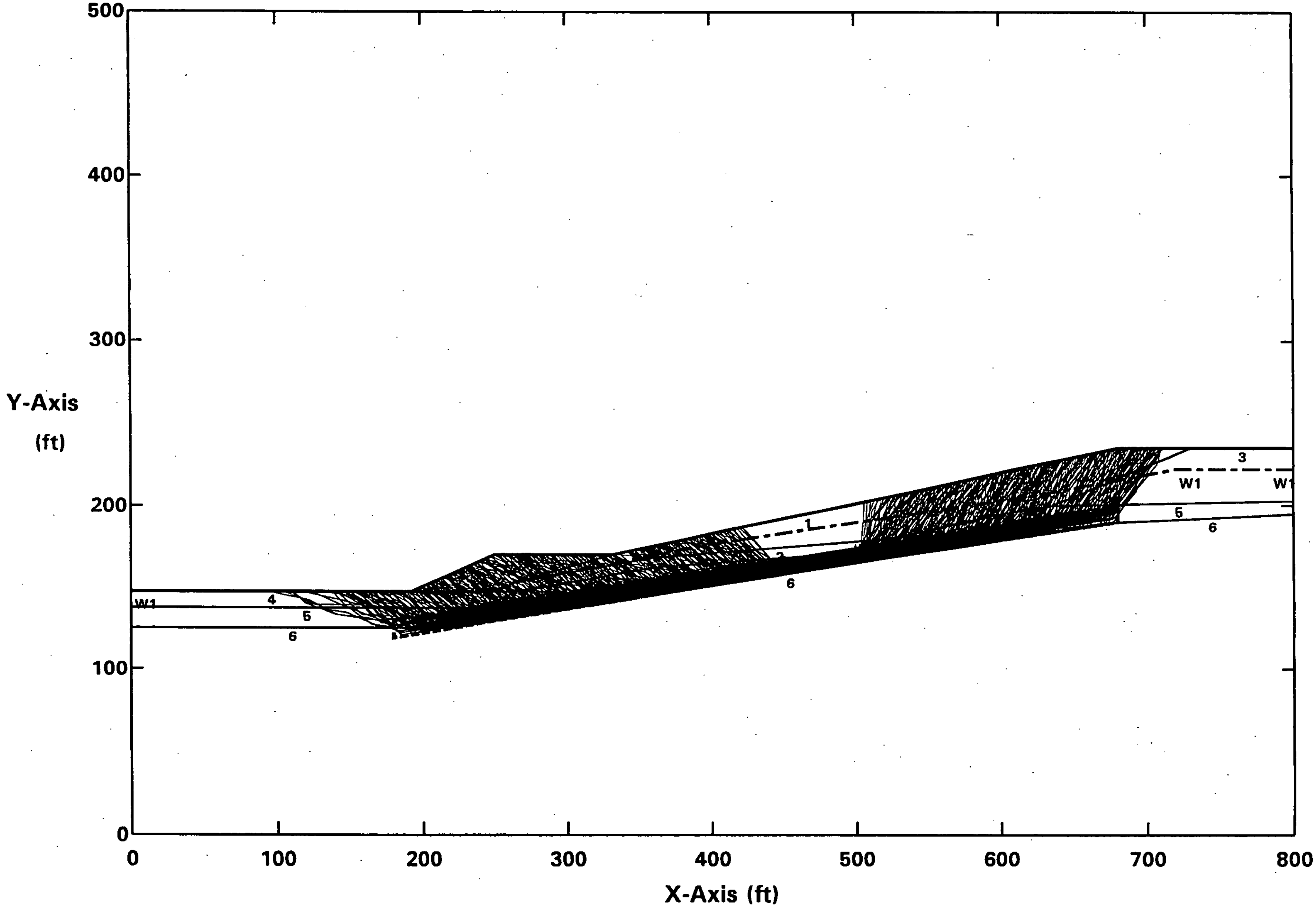
Label	Soil Type No.	Total Unit Wt. (pcf)	Saturated Unit Wt. (pcf)	Cohesion Intercept (psf)	Friction Angle (deg)	Pore Pressure Param.	Pressure Constant (psf)	Piez. Surface No.
WSTE/FIL	1	120	125	50	30	0	0	W1
Qc/SLIDE	2	120	125	0	15	0	0	W1
Qrf	3	120	125	200	30	0	0	W1
Qal	4	125	130	0	33	0	0	W1
WCS	5	120	125	0	15	0	0	W1
UCS	6	125	130	600	30	0	0	W1
ENG FILL	7	130	135	200	35	0	0	W1



PCSTABL5M/SI FS=1.05 Theta=6.9 X-Axis (ft)
Factors Of Safety Calculated By Spencer`s Method of Slices

238

ROCKY FLATS OLF - M&E B 18%W/BM - WCS= 15 deg - W/HIGHGW - SLIDING BLOCK - 0.06g
All surfaces evaluated. C:BBHS06.PLT By: STAN KLINE 10-24-04 6:24pm

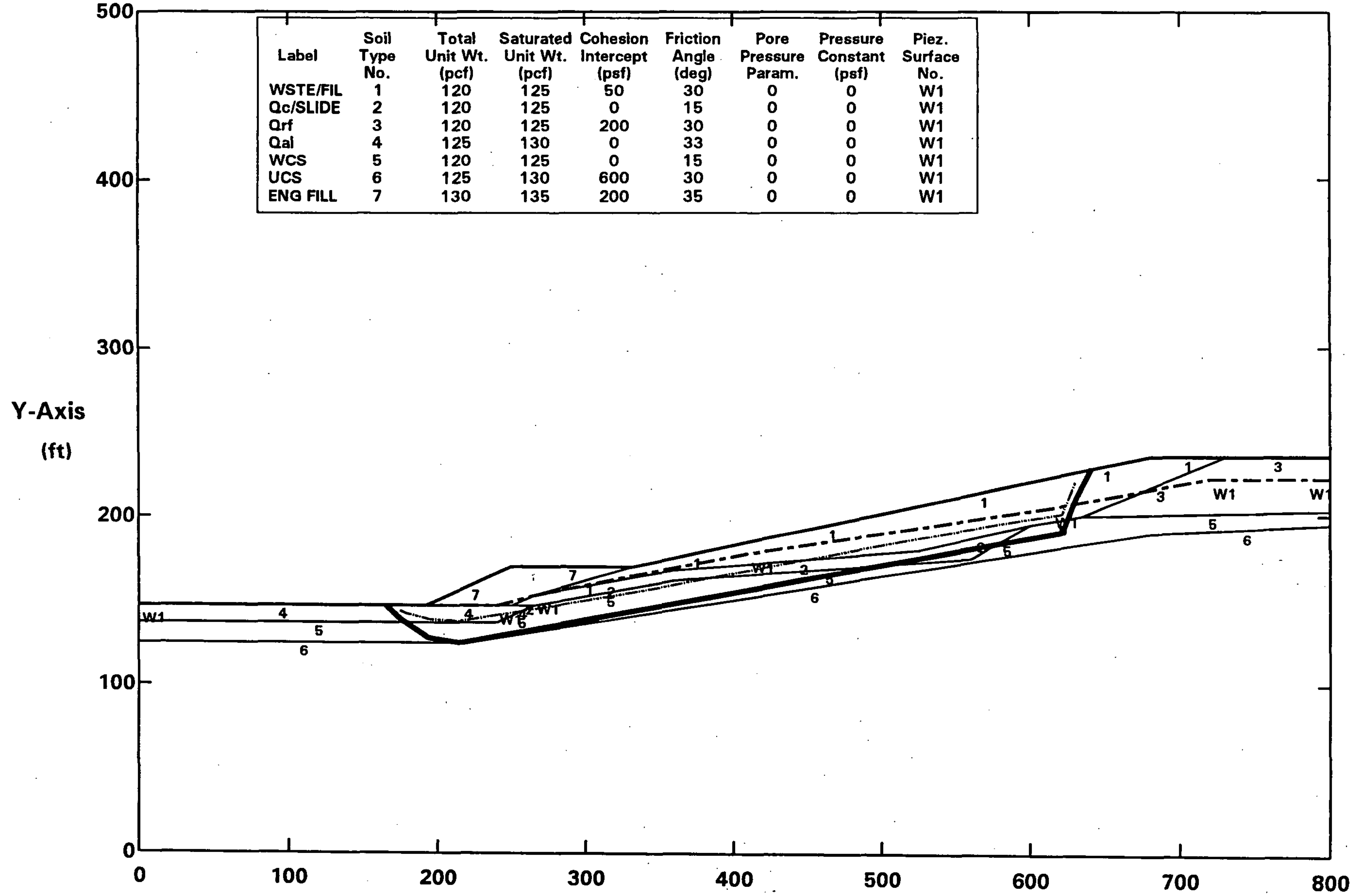


Factors Of Safety Calculated By The Modified Janbu Method

239

ROCKY FLATS OLF - M&E B 18%W/BM - WCS=15 deg - W/HIGHGW - SLIDING BLOCK - 0.06g
Surface #1-BBHS06.OUT. C:BBHS06SP.PLT By: STAN KLINE 10-24-04 6:27pm

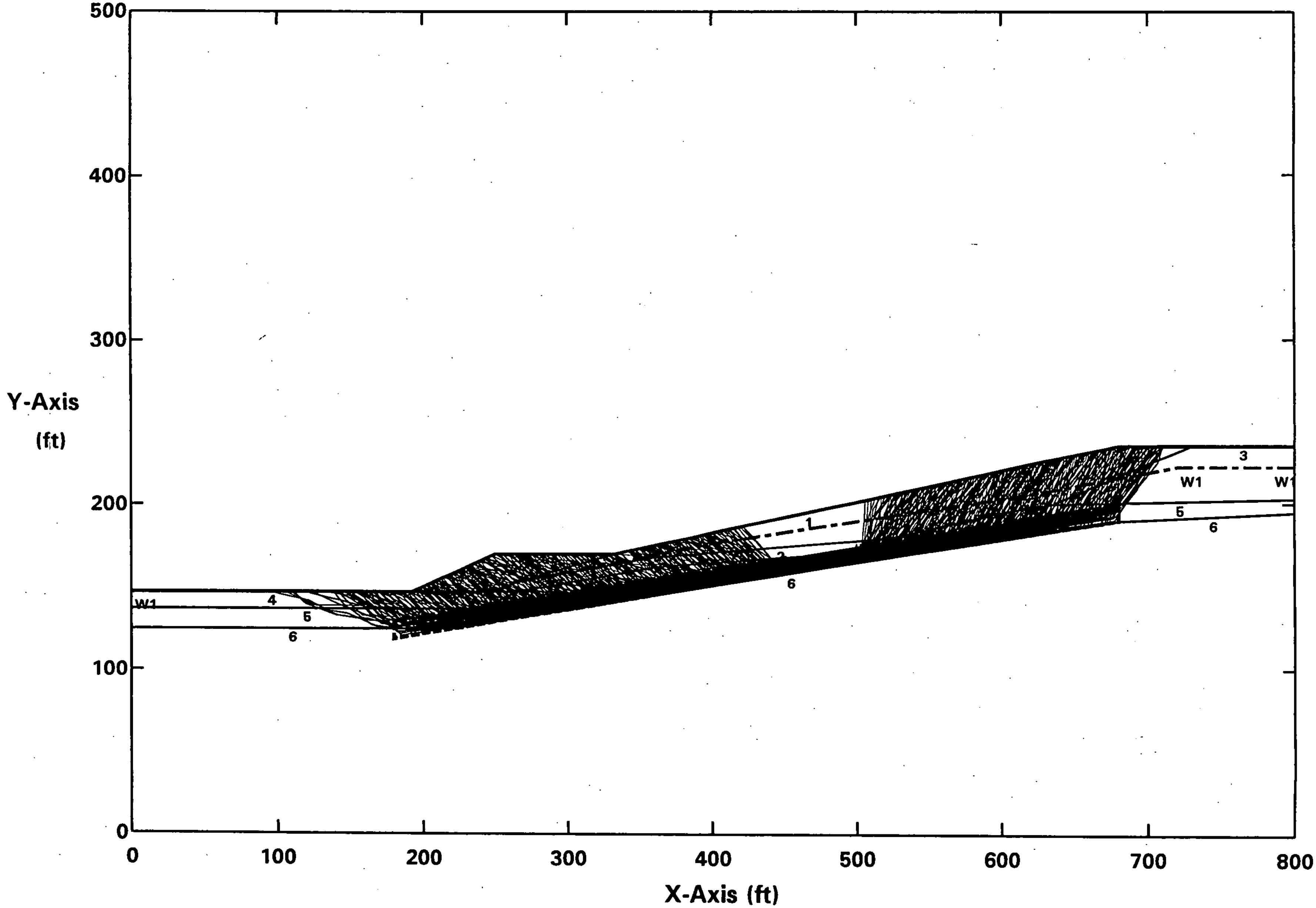
Label	Soil Type No.	Total Unit Wt. (pcf)	Saturated Unit Wt. (pcf)	Cohesion Intercept (psf)	Friction Angle (deg)	Pore Pressure Param.	Pressure Constant (psf)	Piez. Surface No.
WSTE/FIL	1	120	125	50	30	0	0	W1
Qc/SLIDE	2	120	125	0	15	0	0	W1
Qrf	3	120	125	200	30	0	0	W1
Qal	4	125	130	0	33	0	0	W1
WCS	5	120	125	0	15	0	0	W1
UCS	6	125	130	600	30	0	0	W1
ENG FILL	7	130	135	200	35	0	0	W1



PCSTABL5M/SI FS=0.92 Theta=7.5 X-Axis (ft)
Factors Of Safety Calculated By Spencer`s Method of Slices

24D

ROCKY FLATS OLF - M&E B 18%W/BM - WCS= 15 deg - W/HIGHGW - SLIDING BLOCK - 0.04g
All surfaces evaluated. C:BBHS04.PLT By: STAN KLINE 10-24-04 6:11pm

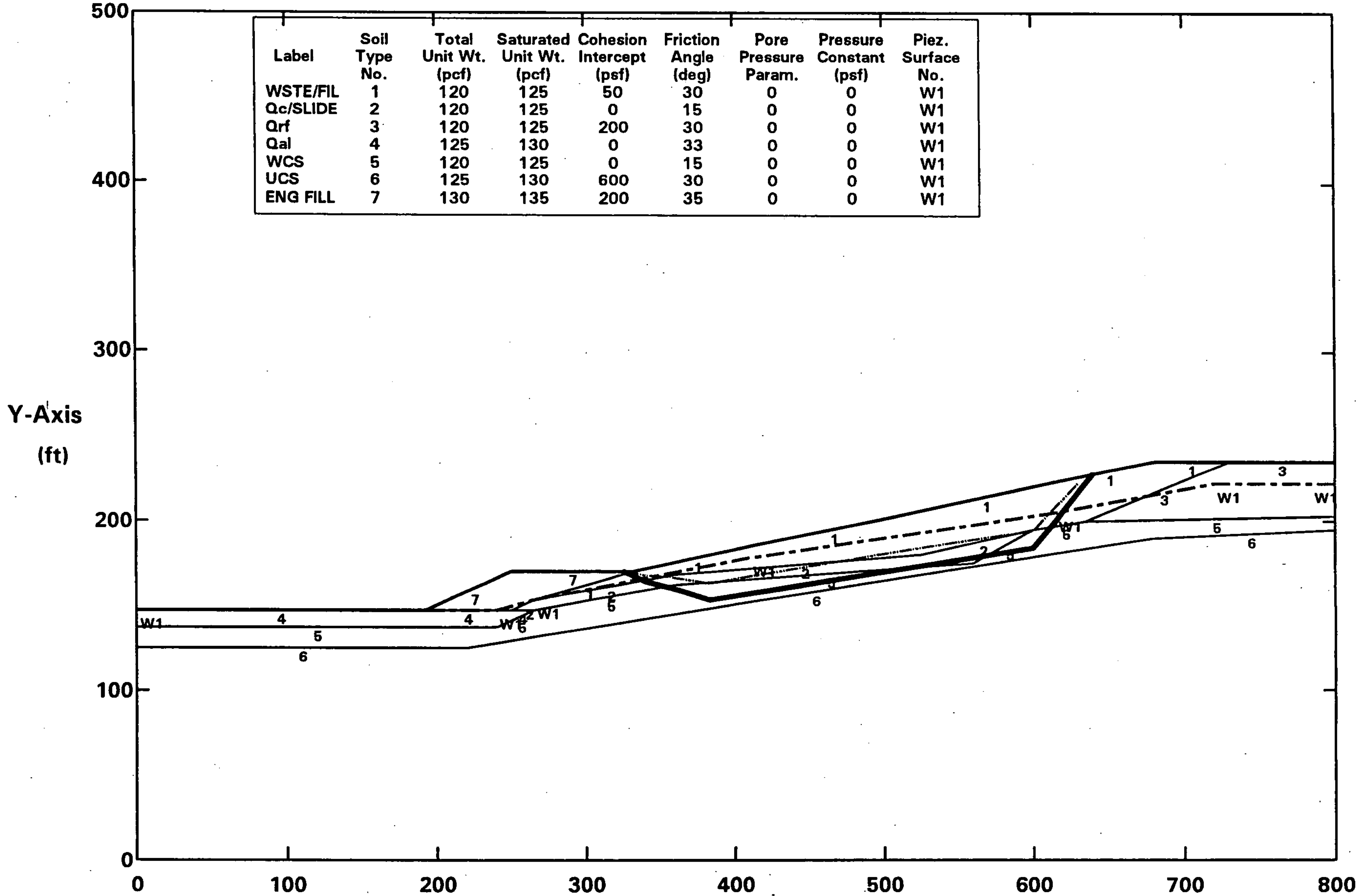


Factors Of Safety Calculated By The Modified Janbu Method

344

ROCKY FLATS OLF - M&E B 18%W/BM - WCS=15 deg - W/HIGHGW - SLIDING BLOCK - 0.04g
Surface #1-BBHS04.OUT. C:BBHS04SP.PLT By: STAN KLINE 10-24-04 6:13pm

Label	Soil Type No.	Total Unit Wt. (pcf)	Saturated Unit Wt. (pcf)	Cohesion Intercept (psf)	Friction Angle (deg)	Pore Pressure Param.	Pressure Constant (psf)	Piez. Surface No.
WSTE/FIL	1	120	125	50	30	0	0	W1
Qc/SLIDE	2	120	125	0	15	0	0	W1
Qrf	3	120	125	200	30	0	0	W1
Qal	4	125	130	0	33	0	0	W1
WCS	5	120	125	0	15	0	0	W1
UCS	6	125	130	600	30	0	0	W1
ENG FILL	7	130	135	200	35	0	0	W1



PCSTABL5M/SI FS=1.01 Theta=7.89 X-Axis (ft)
Factors Of Safety Calculated By Spencer`s Method of Slices

M&E SECTION C-C' – PSEUDOSTATIC

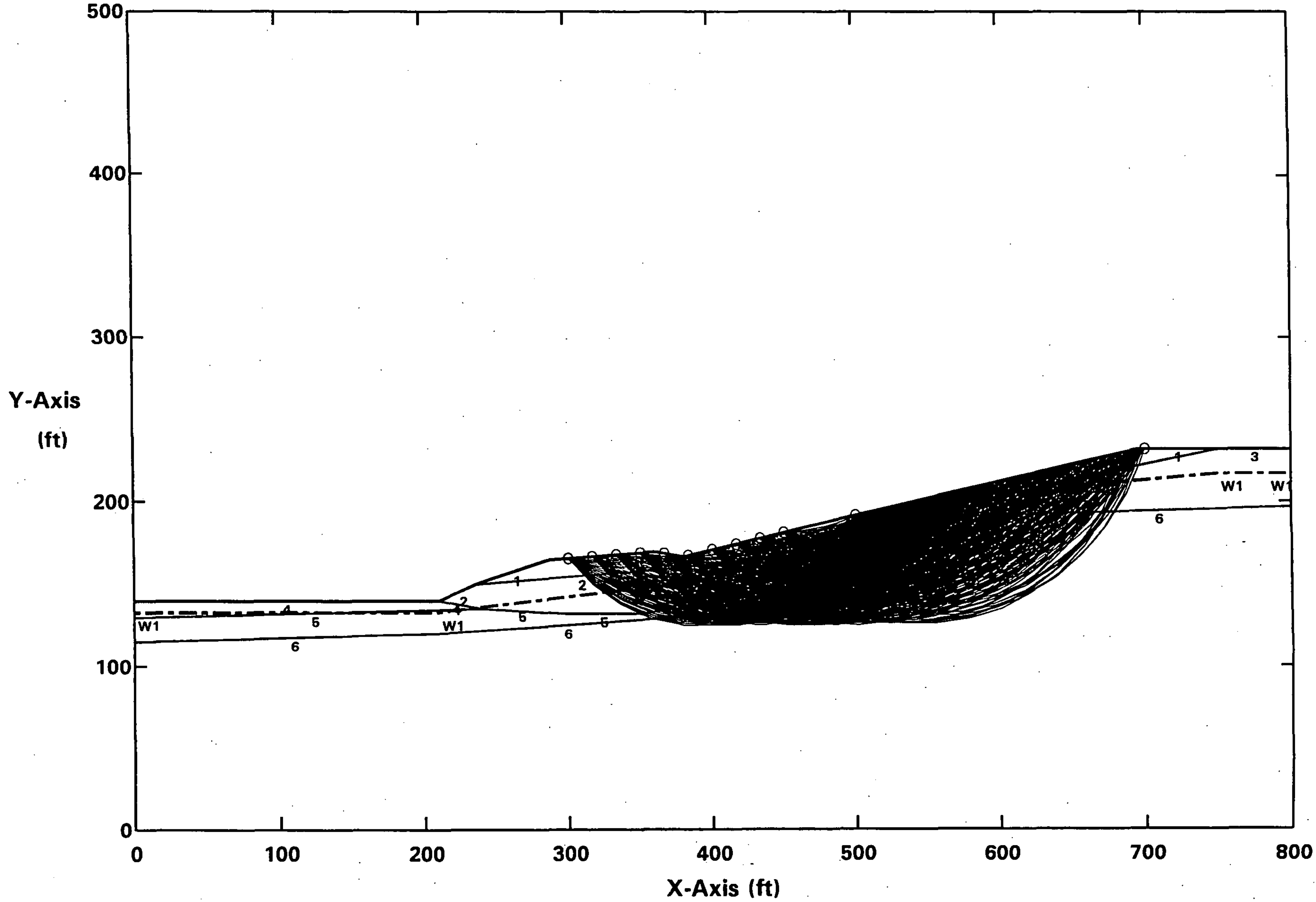
242

EXISTING CONDITIONS

243

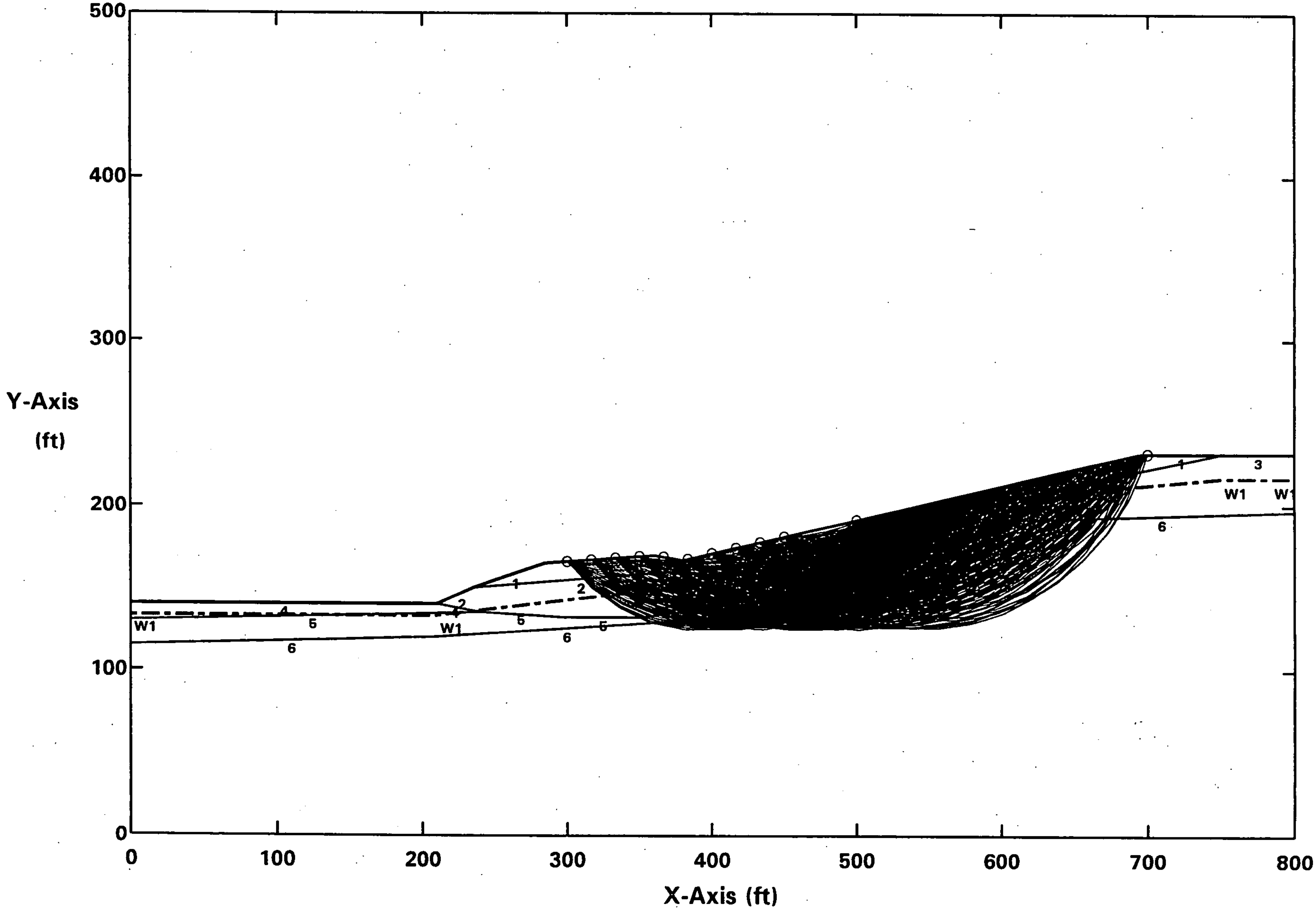
344

ROCKY FLATS OLF - M&E SECTION C - WCS = 15 deg - W/AVEGW - CIRCULAR - 0.01g
All surfaces evaluated. C:CEAC01.PLT By: STAN KLINE 10-26-04 12:10am



Factors Of Safety Calculated By The Modified Bishop Method

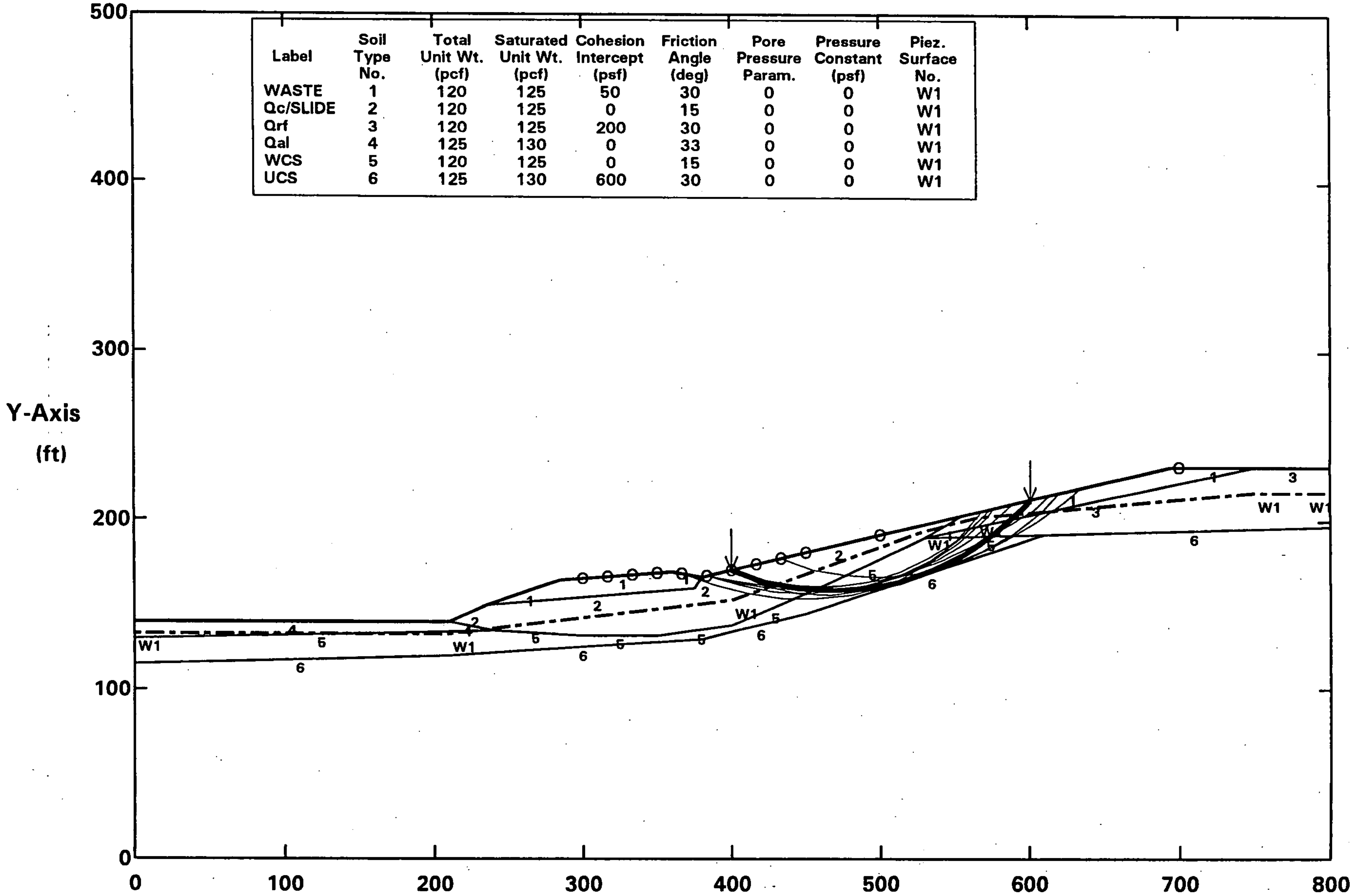
ROCKY FLATS OLF - M&E SECTION C - WCS=15 deg - W/AVEGW - CIRCULAR - 0.06g
All surfaces evaluated. C:CEAC06.PLT By: STAN KLINE 10-26-04 12:11am



Factors Of Safety Calculated By The Modified Bishop Method

245

ROCKY FLATS OLF - M&E SECTION C - WCS = 15 deg - W/AVEGW - CIRCULAR - 0.01g
Ten Most Critical. C:CEAC01.PLT By: STAN KLINE 10-26-04 12:10am



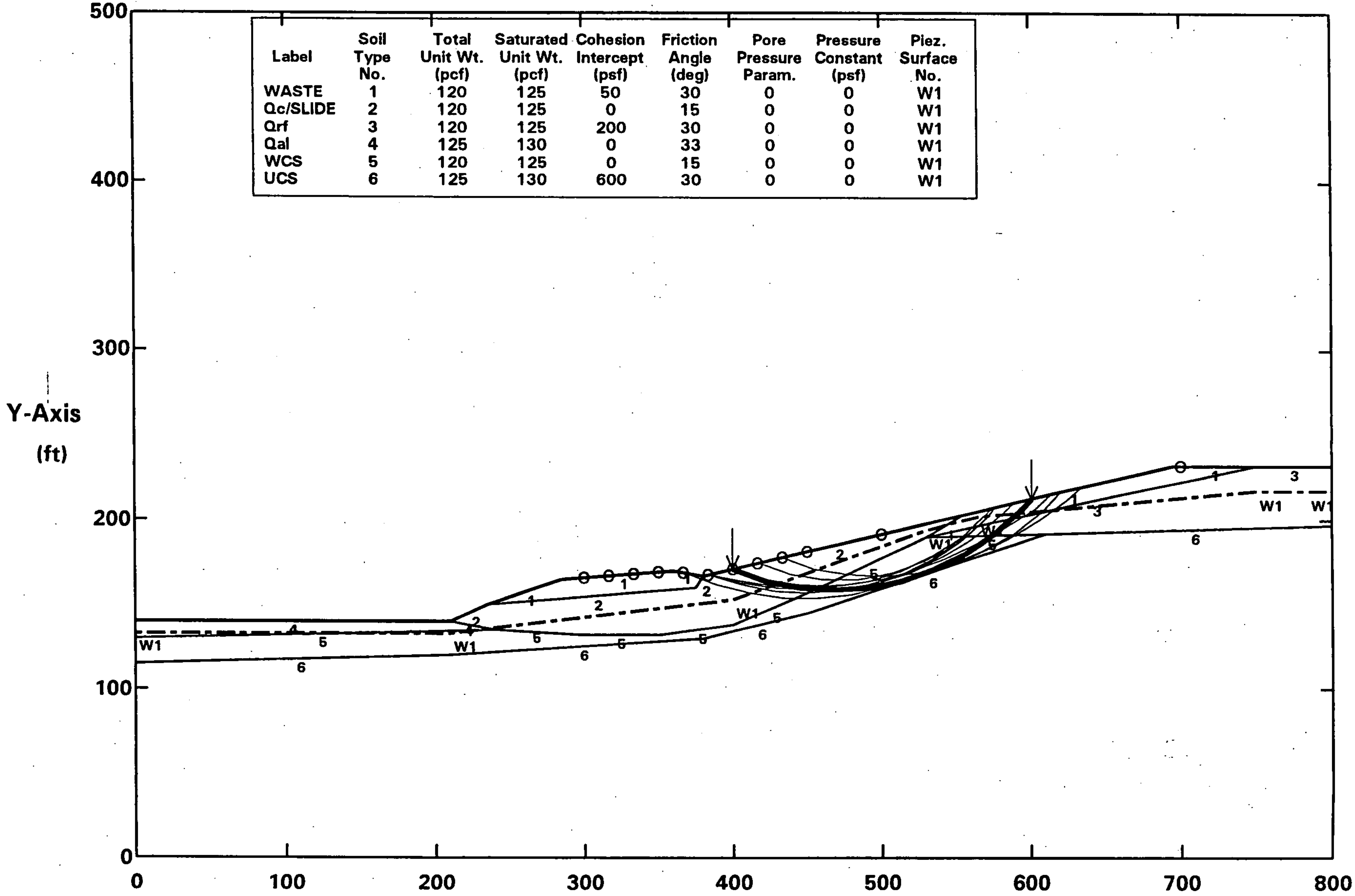
Label	Soil Type No.	Total Unit Wt. (pcf)	Saturated Unit Wt. (pcf)	Cohesion Intercept (psf)	Friction Angle (deg)	Pore Pressure Param.	Pressure Constant (psf)	Piez. Surface No.
WASTE	1	120	125	50	30	0	0	W1
Qc/SLIDE	2	120	125	0	15	0	0	W1
Qrf	3	120	125	200	30	0	0	W1
Qal	4	125	130	0	33	0	0	W1
WCS	5	120	125	0	15	0	0	W1
UCS	6	125	130	600	30	0	0	W1

PCSTABL5M/SI FSmin = 1.03 X-Axis (ft)
Factors Of Safety Calculated By The Modified Bishop Method

242

ROCKY FLATS OLF - M&E SECTION C - WCS = 15 deg - W/AVEGW - CIRCULAR - 0.06g
Ten Most Critical. C:CEAC06.PLT By: STAN KLINE 10-26-04 12:11am

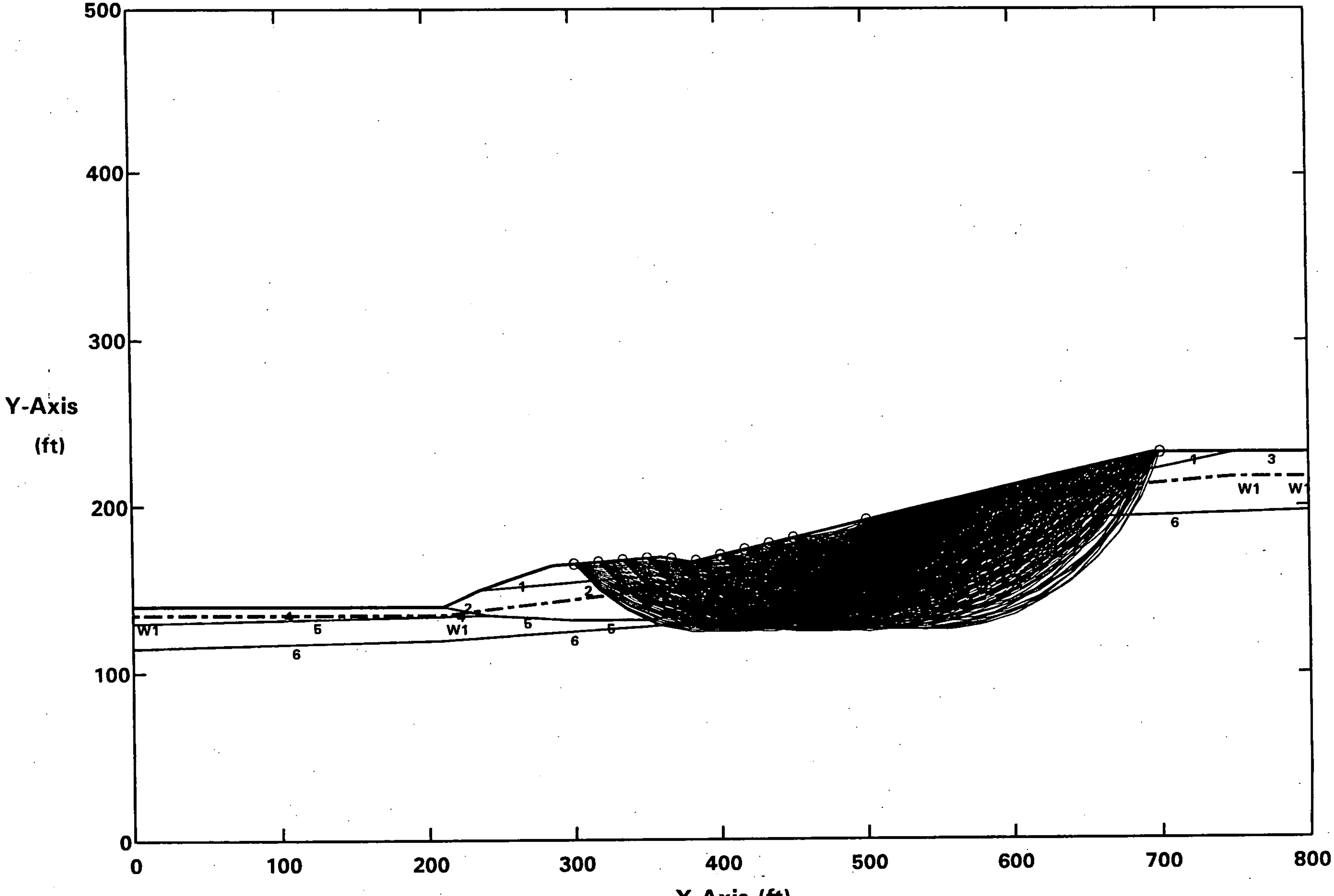
Label	Soil Type No.	Total Unit Wt. (pcf)	Saturated Unit Wt. (pcf)	Cohesion Intercept (psf)	Friction Angle (deg)	Pore Pressure Param.	Pressure Constant (psf)	Piez. Surface No.
WASTE	1	120	125	50	30	0	0	W1
Qc/SLIDE	2	120	125	0	15	0	0	W1
Qrf	3	120	125	200	30	0	0	W1
Qal	4	125	130	0	33	0	0	W1
WCS	5	120	125	0	15	0	0	W1
UCS	6	125	130	600	30	0	0	W1



PCSTABL5M/SI FSmin = 0.83 X-Axis (ft)
Factors Of Safety Calculated By The Modified Bishop Method

248

ROCKY FLATS OLF - M&E SECTION C - WCS = 15 deg - W/HIGHGW - CIRCULAR - 0.06g
All surfaces evaluated. C:CEHC06.PLT By: STAN KLINE 10-26-04 12:15am

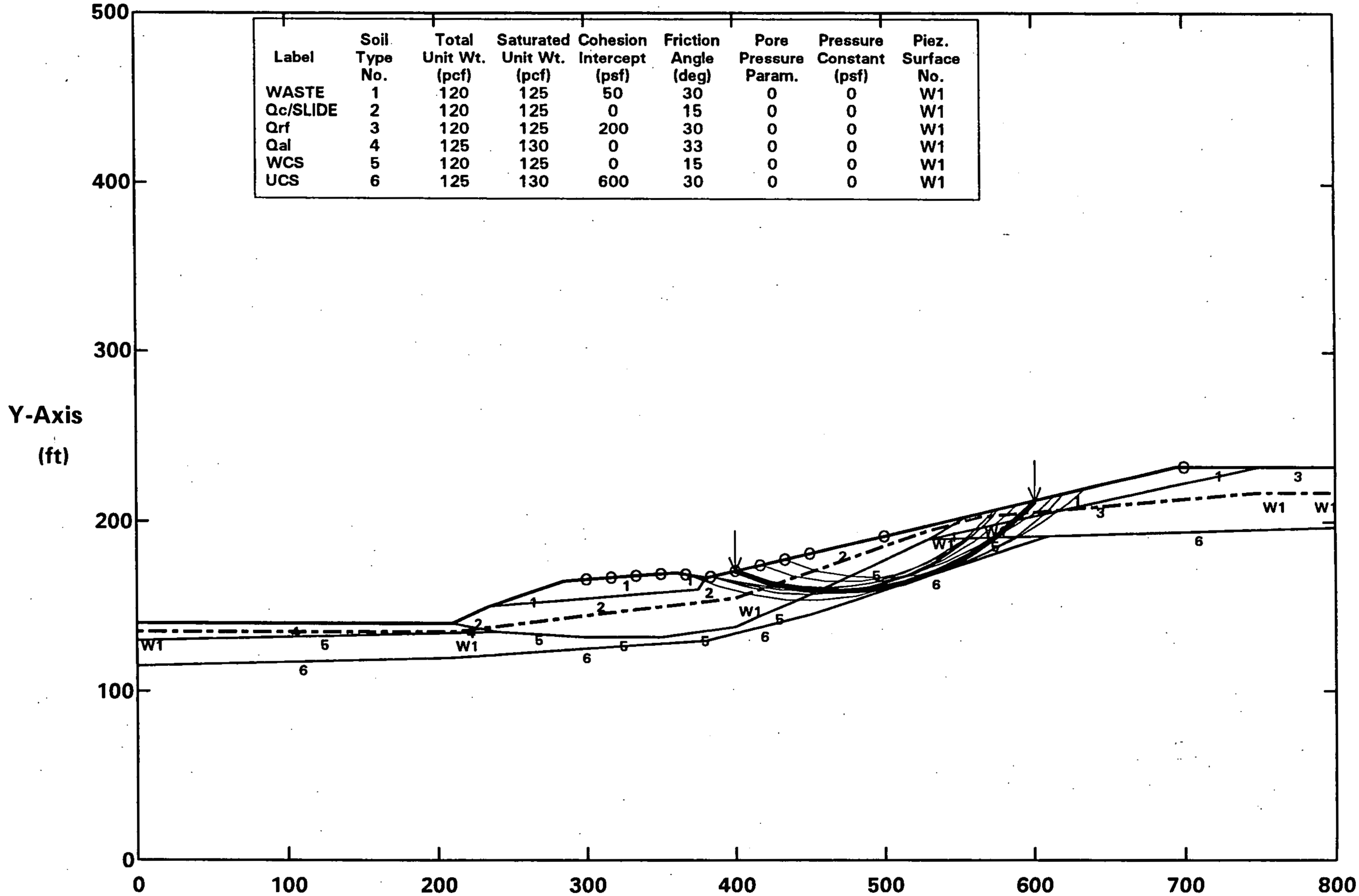


Factors Of Safety Calculated By The Modified Bishop Method

249

ROCKY FLATS OLF - M&E SECTION C - WCS = 15 deg - W/HIGHGW - CIRCULAR - 0.06g
Ten Most Critical. C:CEHC06.PLT By: STAN KLINE 10-26-04 12:15am

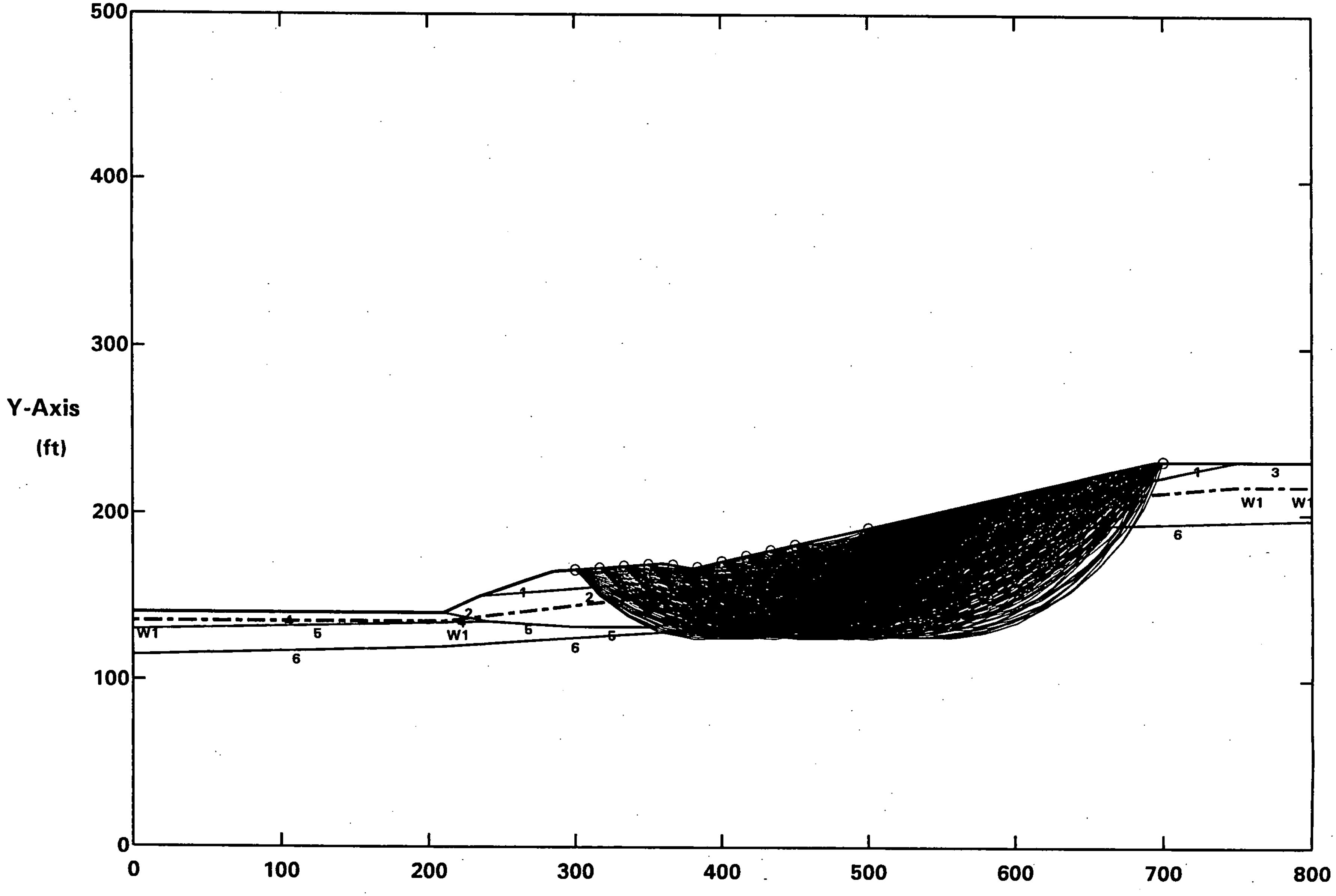
Label	Soil Type No.	Total Unit Wt. (pcf)	Saturated Unit Wt. (pcf)	Cohesion Intercept (psf)	Friction Angle (deg)	Pore Pressure Param.	Pressure Constant (psf)	Piez. Surface No.
WASTE	1	120	125	50	30	0	0	W1
Qc/SLIDE	2	120	125	0	15	0	0	W1
Qrf	3	120	125	200	30	0	0	W1
Qal	4	125	130	0	33	0	0	W1
WCS	5	120	125	0	15	0	0	W1
UCS	6	125	130	600	30	0	0	W1



PCSTABL5M/SI FSmin = 0.80 X-Axis (ft)
Factors Of Safety Calculated By The Modified Bishop Method

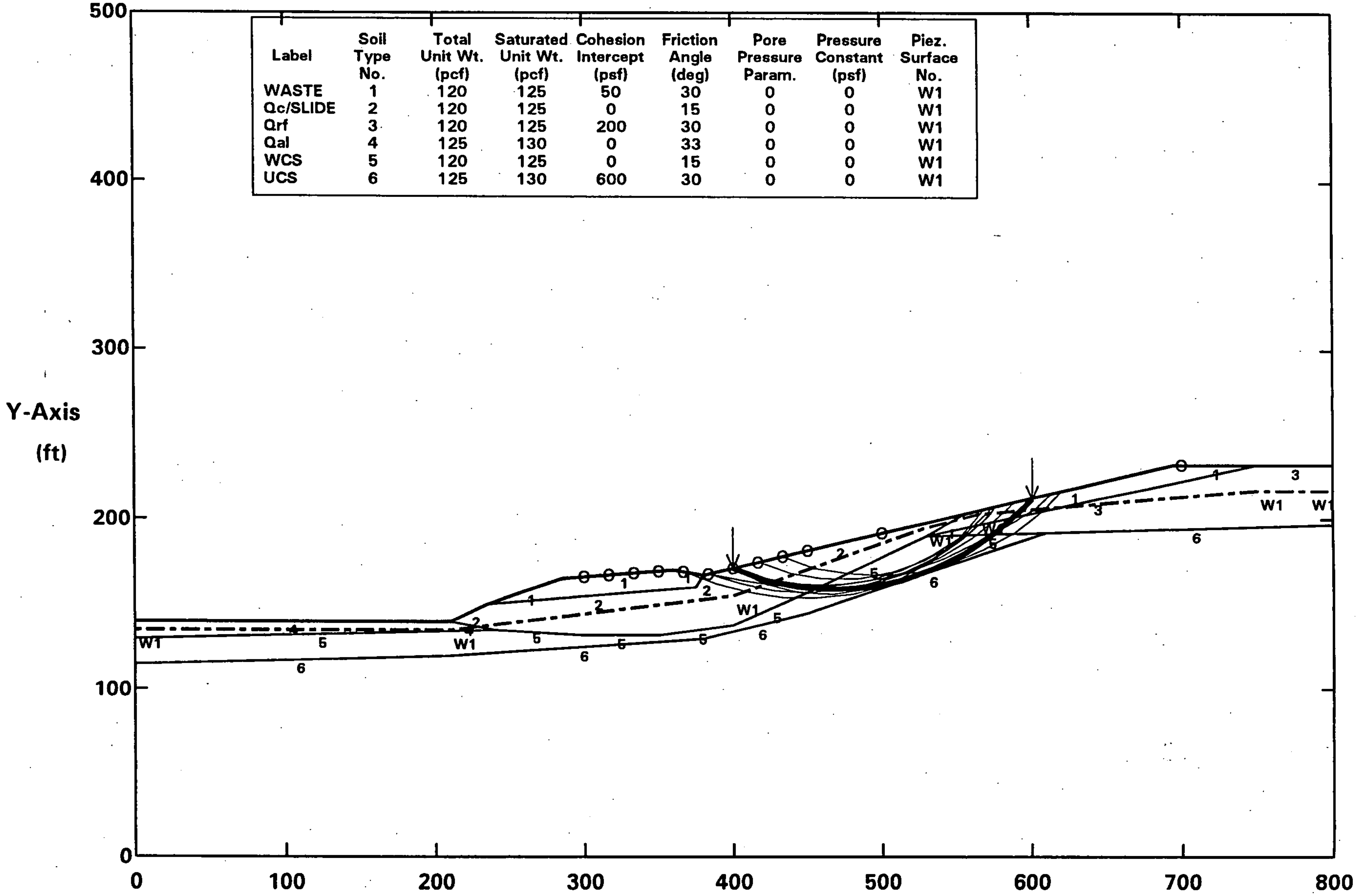
25-2

ROCKY FLATS OLF - M&E SECTION C - WCS = 15 deg - W/HIGHGW - CIRCULAR - 0.01g
All surfaces evaluated. C:CEHC01.PLT By: STAN KLINE 10-26-04 12:14am



Factors Of Safety Calculated By The Modified Bishop Method

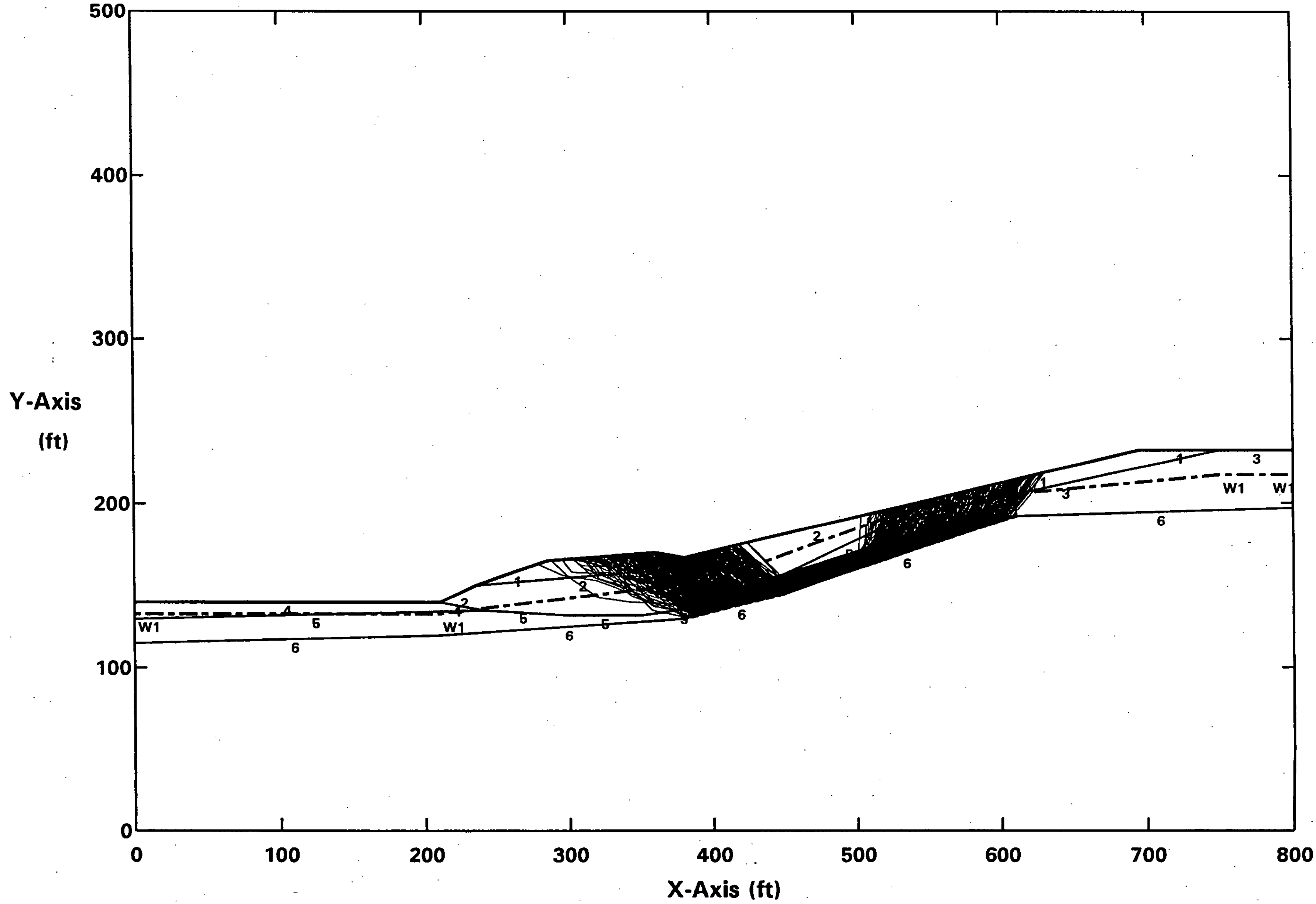
ROCKY FLATS OLF - M&E SECTION C - WCS = 15 deg - W/HIGHGW - CIRCULAR - 0.01g
Ten Most Critical. C:CEHC01.PLT By: STAN KLINE 10-26-04 12:14am



Label	Soil Type No.	Total Unit Wt. (pcf)	Saturated Unit Wt. (pcf)	Cohesion Intercept (psf)	Friction Angle (deg)	Pore Pressure Param.	Pressure Constant (psf)	Piez. Surface No.
WASTE	1	120	125	50	30	0	0	W1
Qc/SLIDE	2	120	125	0	15	0	0	W1
Qrf	3	120	125	200	30	0	0	W1
Qal	4	125	130	0	33	0	0	W1
WCS	5	120	125	0	15	0	0	W1
UCS	6	125	130	600	30	0	0	W1

PCSTABL5M/SI FSmin = 1.00 X-Axis (ft)
Factors Of Safety Calculated By The Modified Bishop Method

ROCKY FLATS OLF - M&E SECTION C - WCS = 15 deg - W/AVEGW - SLIDING BLOCK - 0.06g
All surfaces evaluated. C:CEAS06.PLT By: STAN KLINE 10-24-04 6:52pm

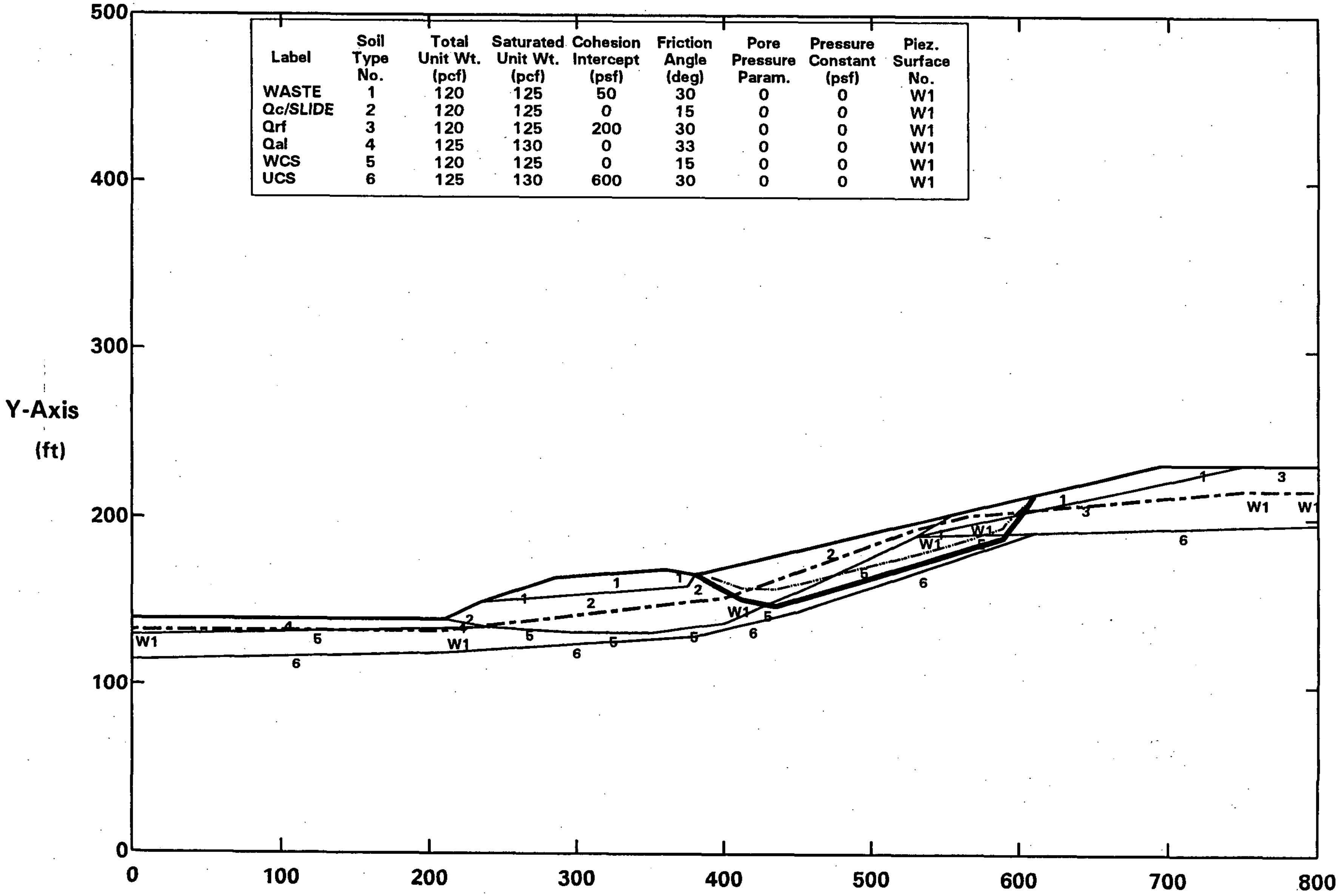


Factors Of Safety Calculated By The Modified Janbu Method

252

253

ROCKY FLATS OLF - M&E SECTION C - WCS = 15 deg - W/AVEGW - SLIDING BLOCK - 0.06g
Surface #1-CEAS06.OUT. C:CEAS06SP.PLT By: STAN KLINE 10-24-04 6:54pm

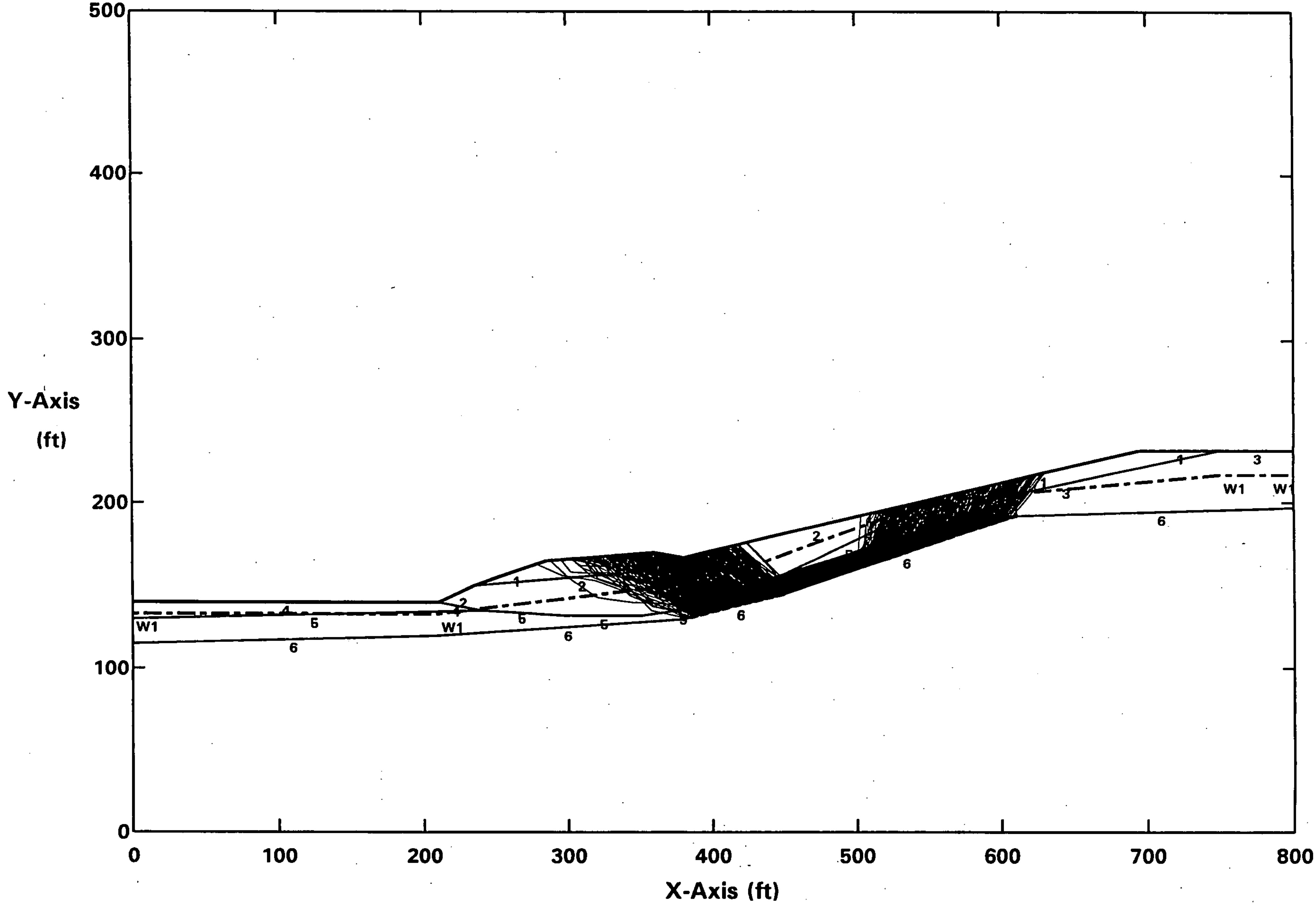


Label	Soil Type No.	Total Unit Wt. (pcf)	Saturated Unit Wt. (pcf)	Cohesion Intercept (psf)	Friction Angle (deg)	Pore Pressure Param.	Pressure Constant (psf)	Piez. Surface No.
WASTE	1	120	125	50	30	0	0	W1
Qc/SLIDE	2	120	125	0	15	0	0	W1
Qrf	3	120	125	200	30	0	0	W1
Qal	4	125	130	0	33	0	0	W1
WCS	5	120	125	0	15	0	0	W1
UCS	6	125	130	600	30	0	0	W1

PCSTABL5M/SI FS = 0.85 Theta = 9.22 X-Axis (ft)
Factors Of Safety Calculated By Spencer`s Method of Slices

254

ROCKY FLATS OLF - M&E SECTION C - WCS= 15 deg - W/AVEGW - SLIDING BLOCK - 0.02g
All surfaces evaluated. C:CEAS02.PLT By: STAN KLINE 10-24-04 6:49pm

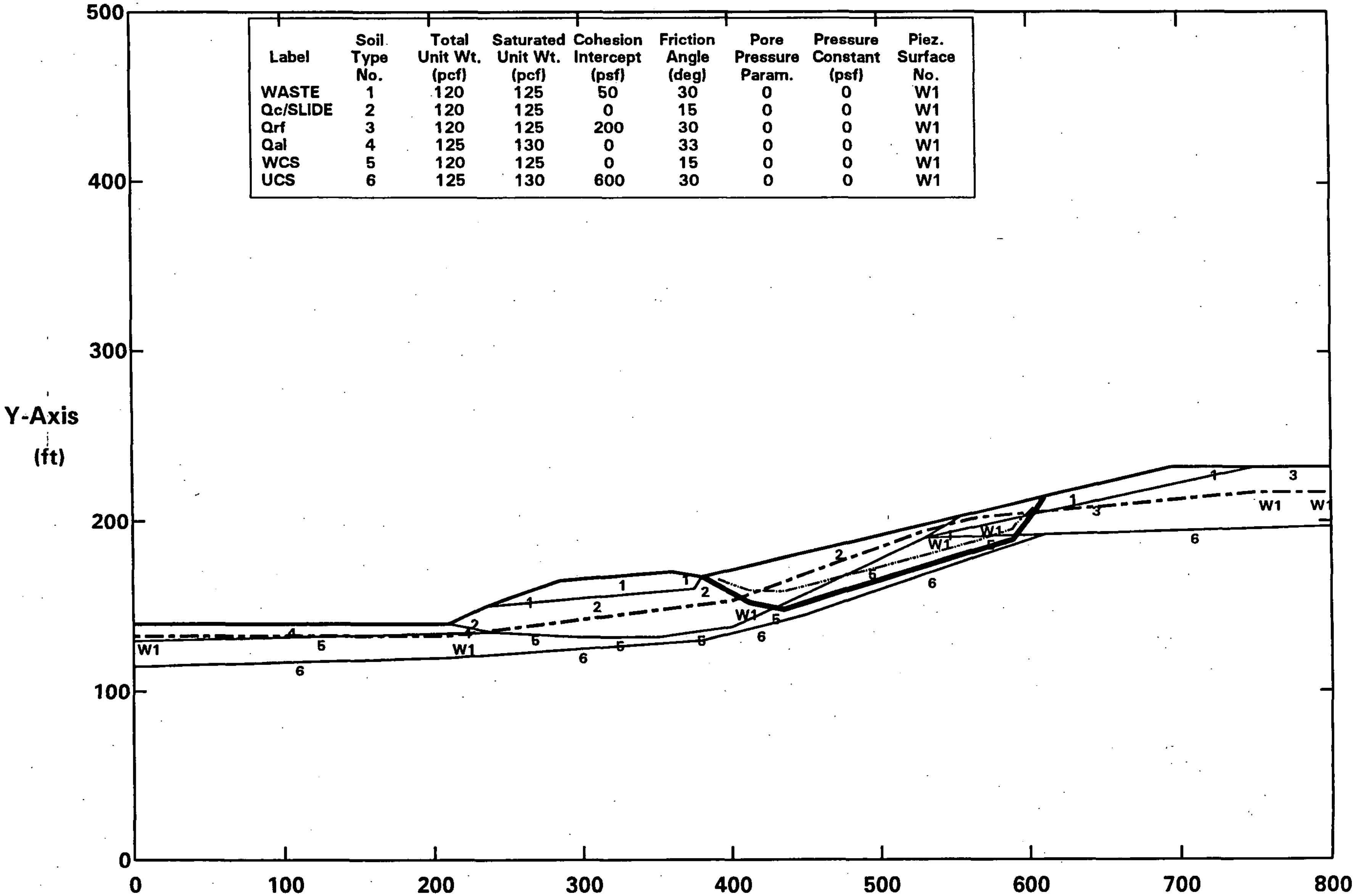


Factors Of Safety Calculated By The Modified Janbu Method

255

ROCKY FLATS OLF - M&E SECTION C - WCS=15 deg - W/AVEGW - SLIDING BLOCK - 0.02g
Surface #1-CEAS02.OUT. C:CEAS02SP.PLT By: STAN KLINE 10-24-04 6:51pm

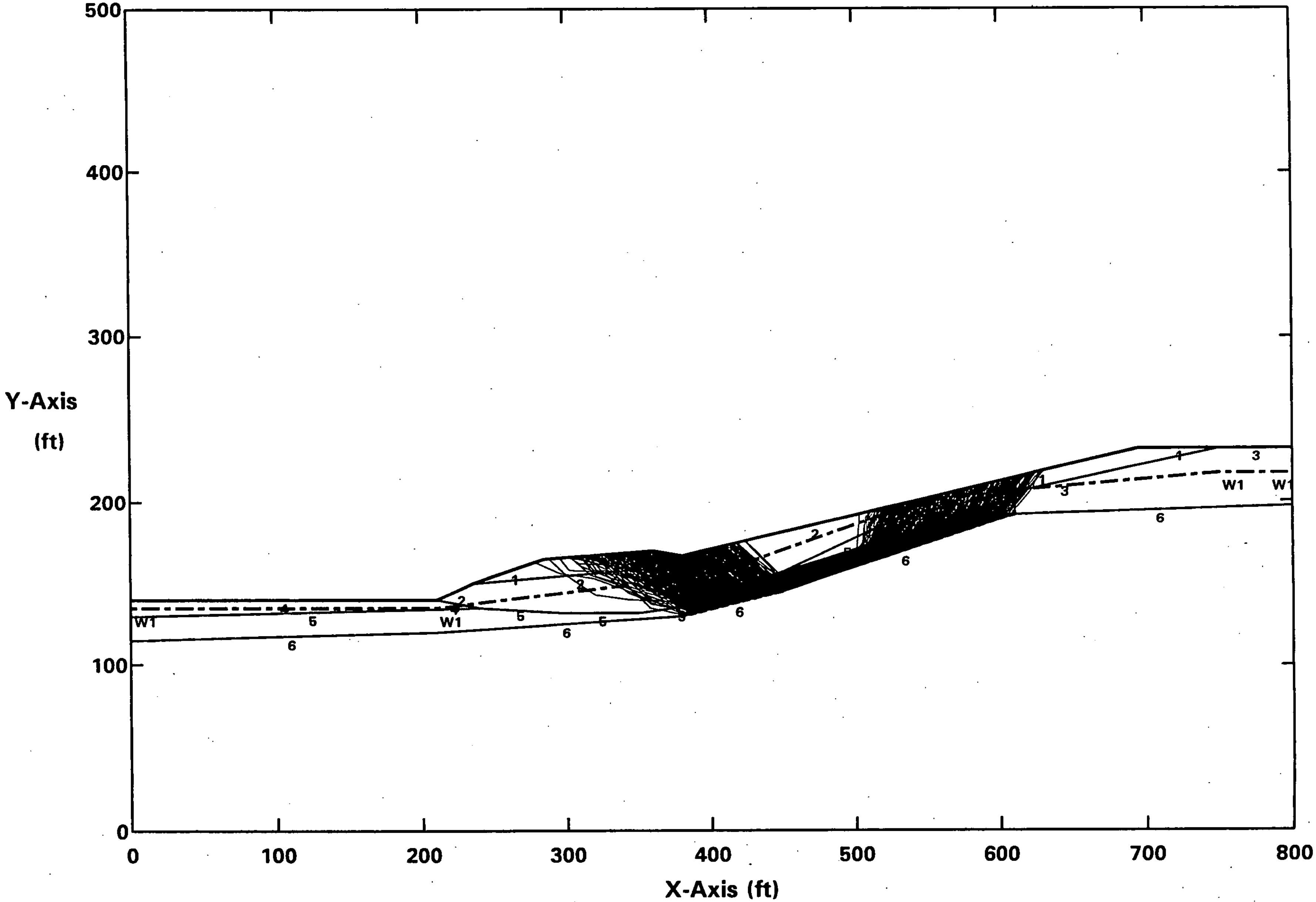
Label	Soil Type No.	Total Unit Wt. (pcf)	Saturated Unit Wt. (pcf)	Cohesion Intercept (psf)	Friction Angle (deg)	Pore Pressure Param.	Pressure Constant (psf)	Piez. Surface No.
WASTE	1	120	125	50	30	0	0	W1
Qc/SLIDE	2	120	125	0	15	0	0	W1
Qrf	3	120	125	200	30	0	0	W1
Qal	4	125	130	0	33	0	0	W1
WCS	5	120	125	0	15	0	0	W1
UCS	6	125	130	600	30	0	0	W1



PCSTABL5M/SI FS=1.02 Theta=9.42 X-Axis (ft)
Factors Of Safety Calculated By Spencer`s Method of Slices

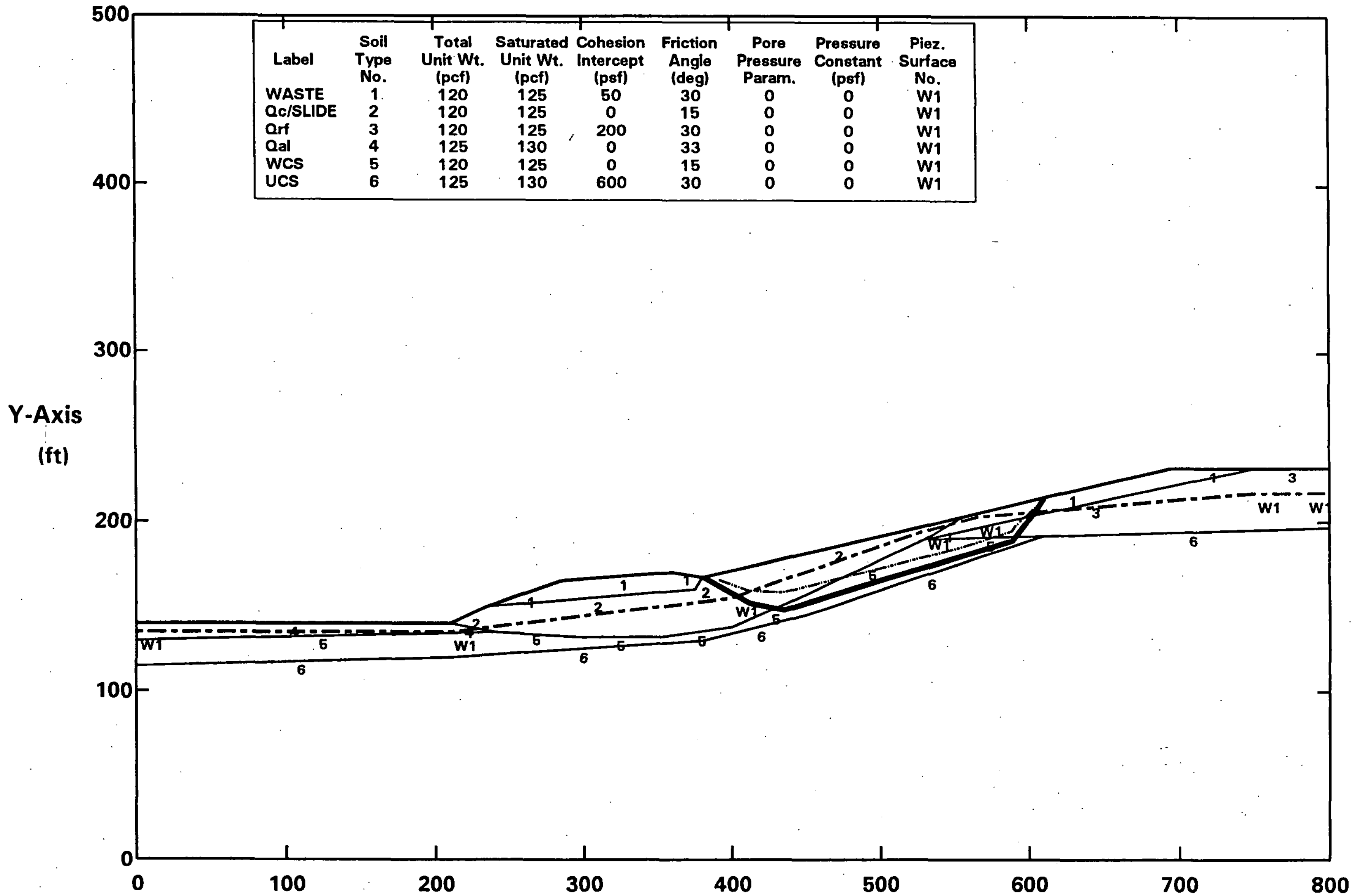
252

ROCKY FLATS OLF - M&E SECTION C - WCS = 15 deg - W/HIGHGW - SLIDING BLOCK - 0.06g
All surfaces evaluated. C:CEHS06.PLT By: STAN KLINE 10-24-04 7:15pm



Factors Of Safety Calculated By The Modified Janbu Method

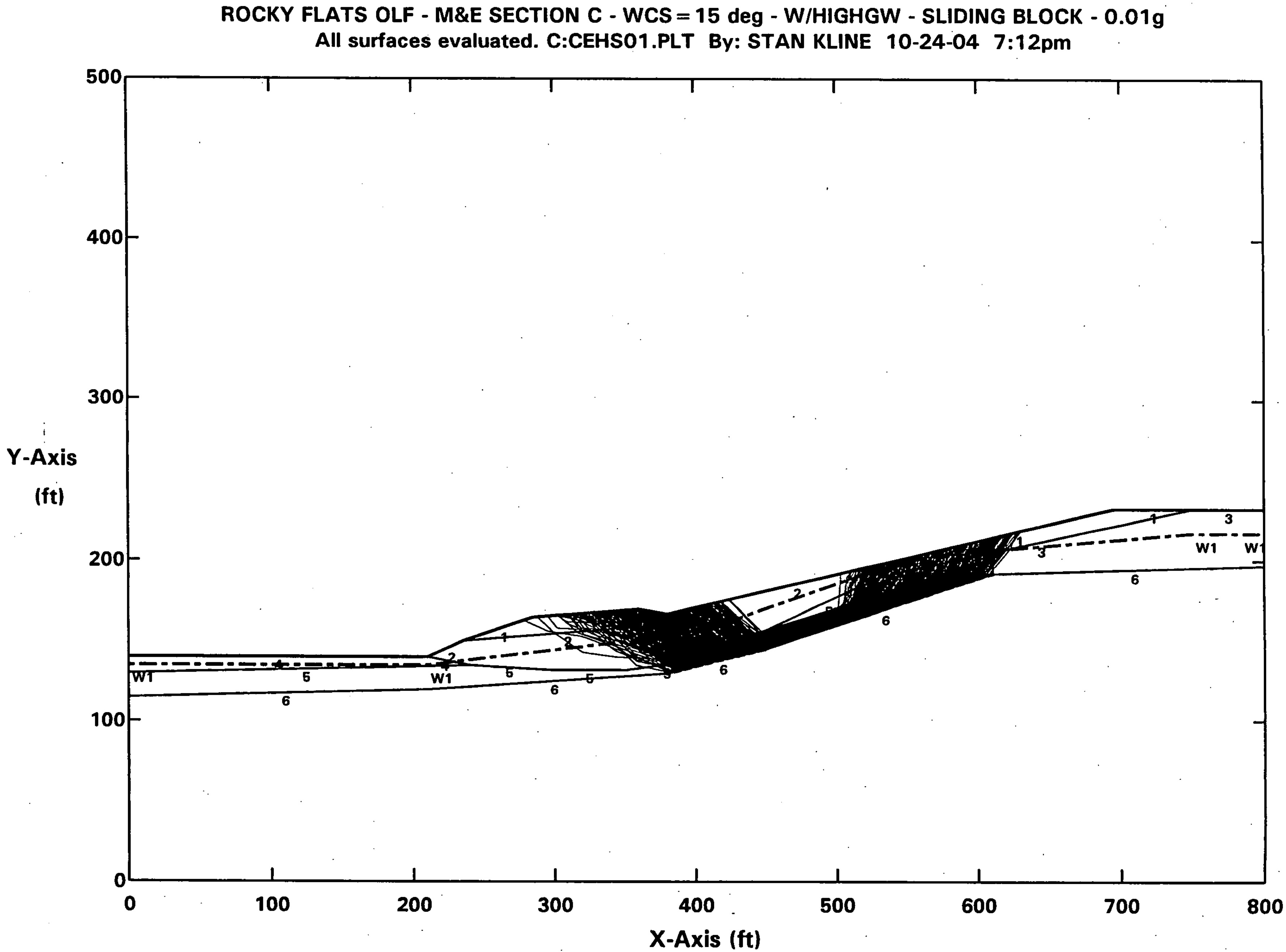
ROCKY FLATS OLF - M&E SECTION C - WCS = 15 deg - W/HIGHGW - SLIDING BLOCK - 0.06g
Surface #1-CEHS06.OUT. C:CEHS06SP.PLT By: STAN KLINE 10-24-04 7:17pm



Label	Soil Type No.	Total Unit Wt. (pcf)	Saturated Unit Wt. (pcf)	Cohesion Intercept (psf)	Friction Angle (deg)	Pore Pressure Param.	Pressure Constant (psf)	Piez. Surface No.
WASTE	1	120	125	50	30	0	0	W1
Qc/SLIDE	2	120	125	0	15	0	0	W1
Qrf	3	120	125	200	30	0	0	W1
Qal	4	125	130	0	33	0	0	W1
WCS	5	120	125	0	15	0	0	W1
UCS	6	125	130	600	30	0	0	W1

PCSTABL5M/SI FS = 0.82 Theta = 9.22 X-Axis (ft)
Factors Of Safety Calculated By Spencer`s Method of Slices

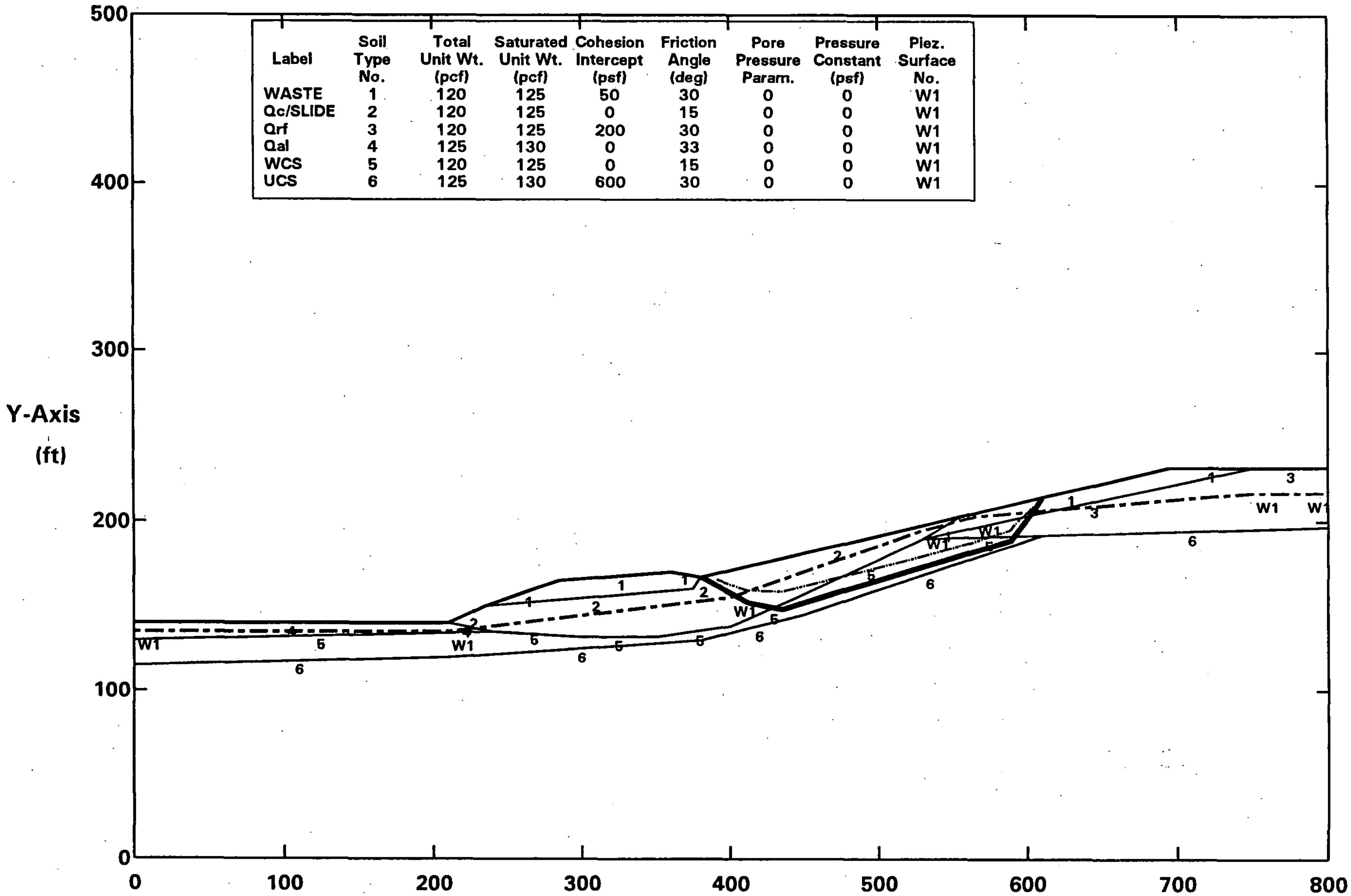
253



Factors Of Safety Calculated By The Modified Janbu Method

254

ROCKY FLATS OLF - M&E SECTION C - WCS = 15 deg - W/HIGHGW - SLIDING BLOCK - 0.01g
Surface #1-CEHS01.OUT. C:CEHS01SP.PLT By: STAN KLINE 10-24-04 7:14pm



Label	Soil Type No.	Total Unit Wt. (pcf)	Saturated Unit Wt. (pcf)	Cohesion Intercept (psf)	Friction Angle (deg)	Pore Pressure Param.	Pressure Constant (psf)	Piez. Surface No.
WASTE	1	120	125	50	30	0	0	W1
Qc/SLIDE	2	120	125	0	15	0	0	W1
Qrf	3	120	125	200	30	0	0	W1
Qal	4	125	130	0	33	0	0	W1
WCS	5	120	125	0	15	0	0	W1
UCS	6	125	130	600	30	0	0	W1

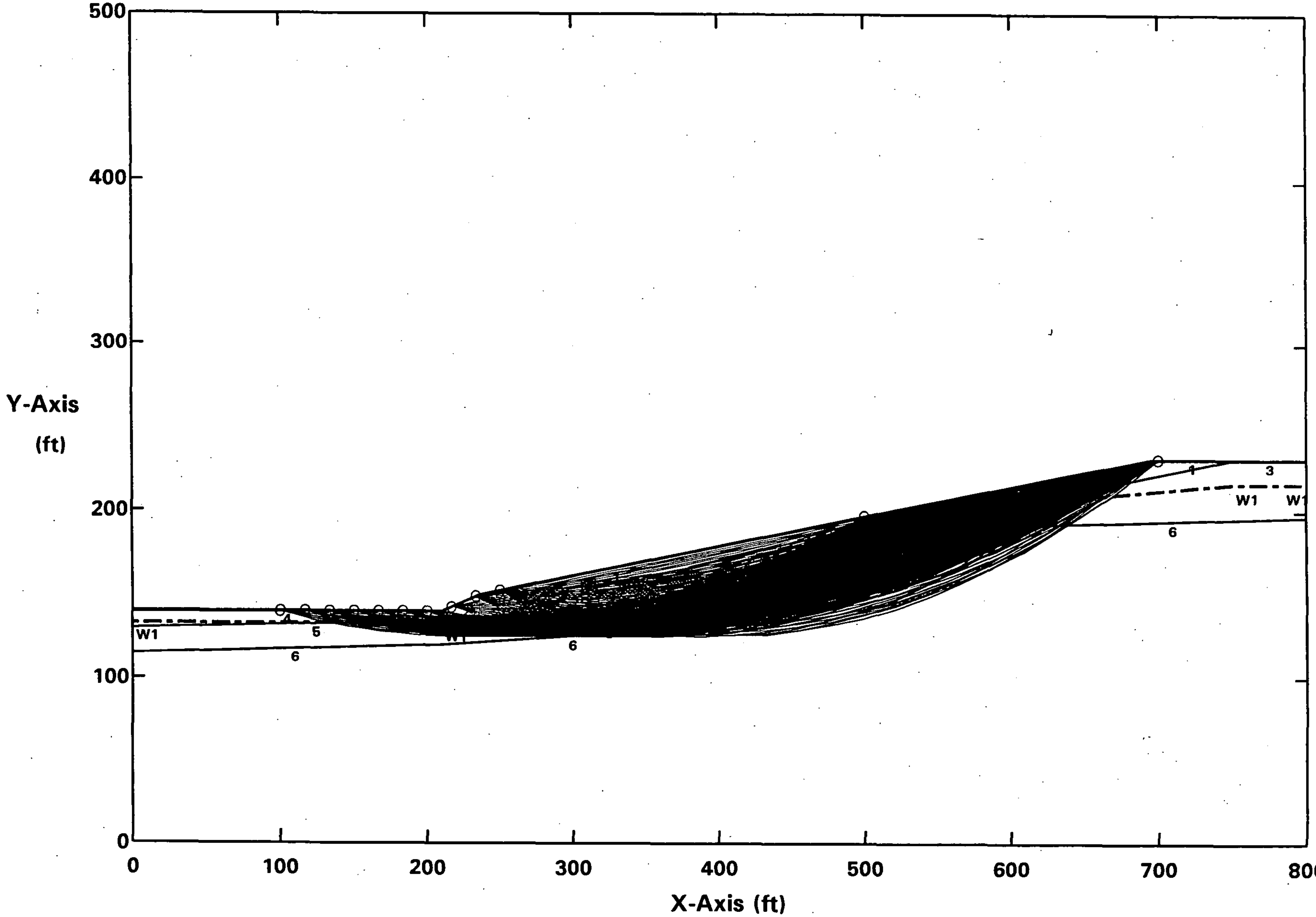
PCSTABL5M/SI FS = 1.04 Theta = 9.49 X-Axis (ft)
Factors Of Safety Calculated By Spencer`s Method of Slices

18% REGRADE CONDITION

260

256

ROCKY FLATS OLF - M&E C 18% GRD - WCS=15 deg - W/AVEGW - CIRCULAR - 0.06g
All surfaces evaluated. C:CGAC06.PLT By: STAN KLINE 10-26-04 12:12am

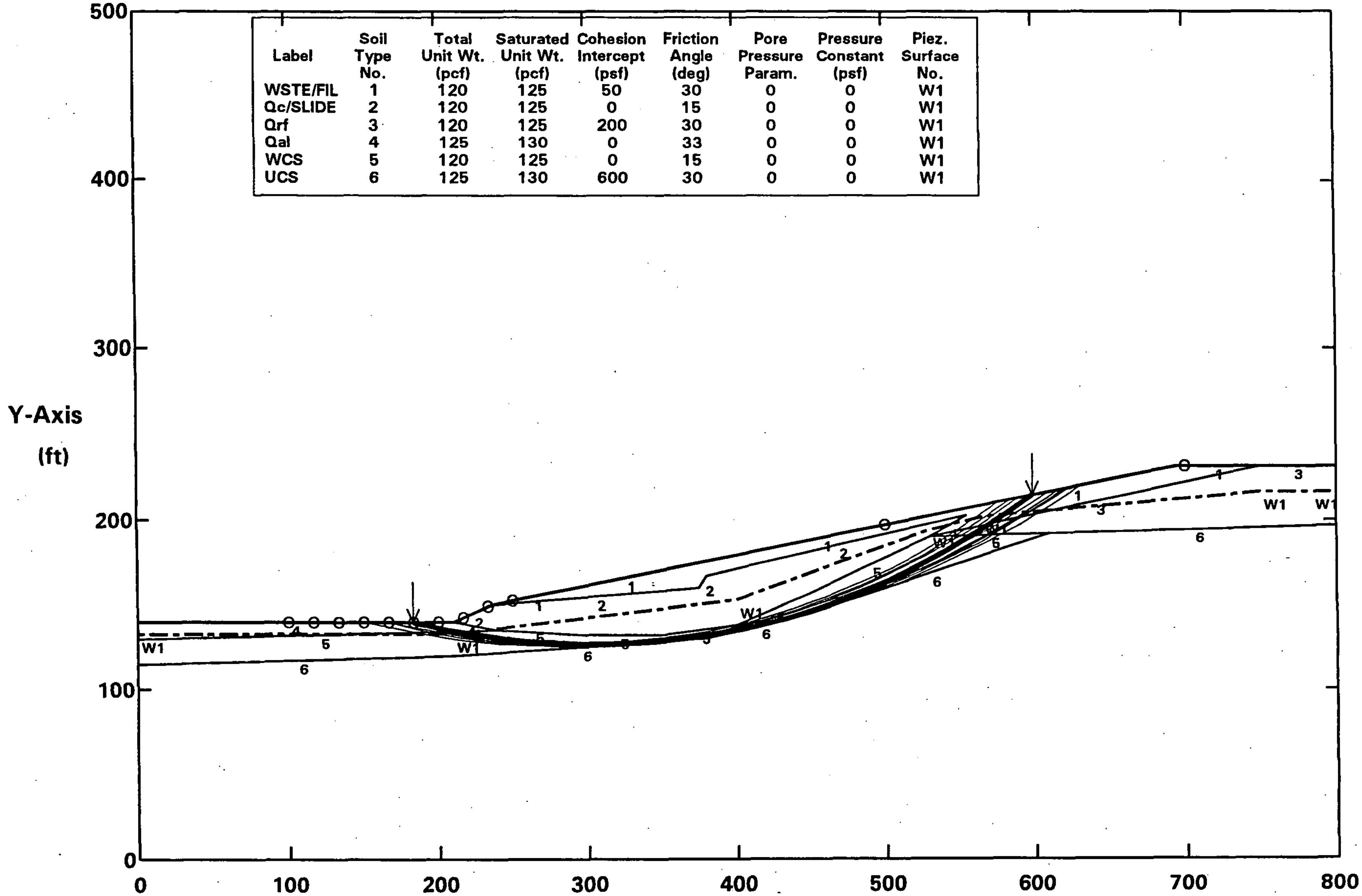


Factors Of Safety Calculated By The Modified Bishop Method

2]6

ROCKY FLATS OLF - M&E C 18% GRD - WCS = 15 deg - W/AVEGW - CIRCULAR - 0.04g
Ten Most Critical. C:CGAC04.PLT By: STAN KLINE 10-26-04 12:12am

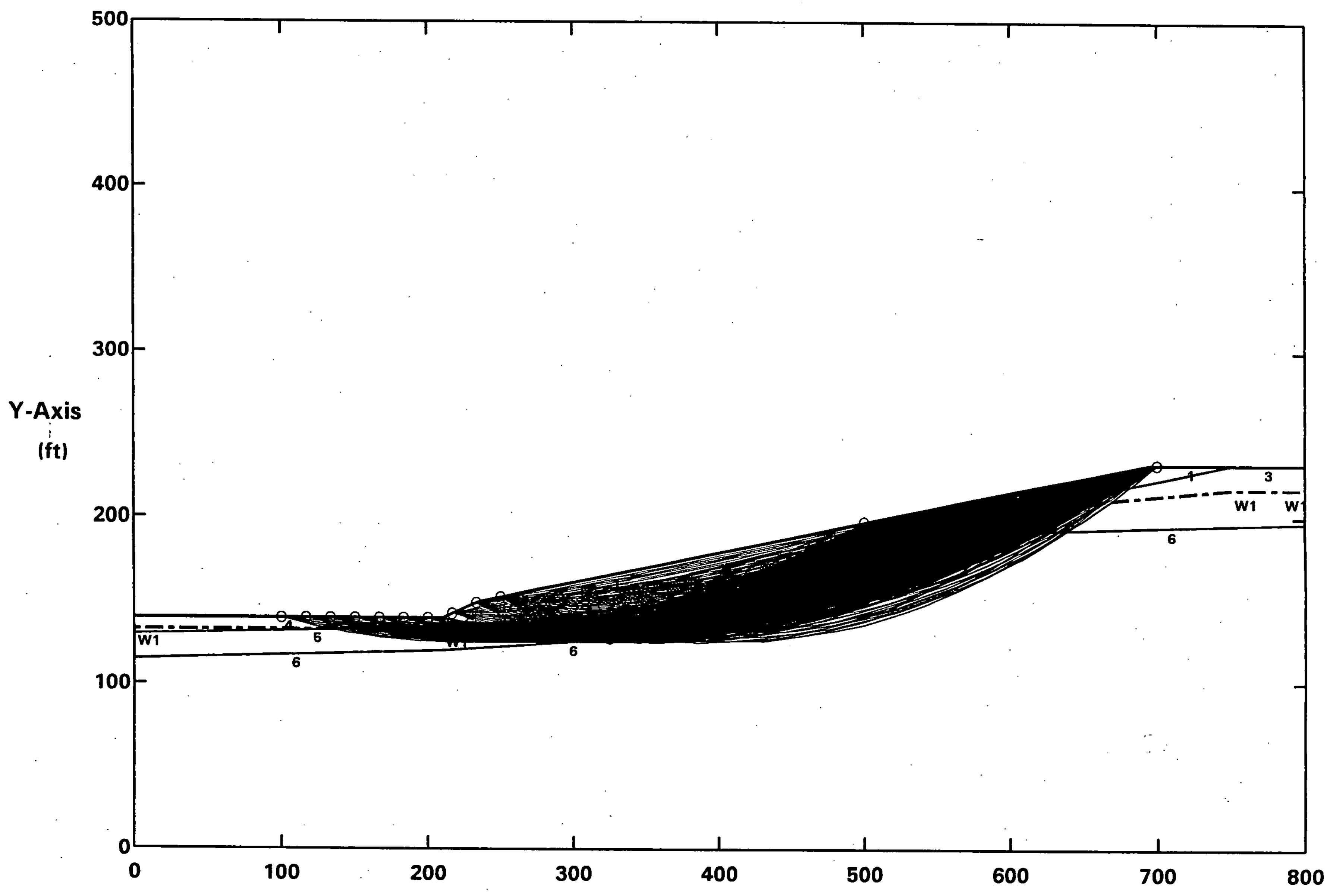
Label	Soil Type No.	Total Unit Wt. (pcf)	Saturated Unit Wt. (pcf)	Cohesion Intercept (psf)	Friction Angle (deg)	Pore Pressure Param.	Pressure Constant (psf)	Piez. Surface No.
WSTE/FIL	1	120	125	50	30	0	0	W1
Qc/SLIDE	2	120	125	0	15	0	0	W1
Qrf	3	120	125	200	30	0	0	W1
Qal	4	125	130	0	33	0	0	W1
WCS	5	120	125	0	15	0	0	W1
UCS	6	125	130	600	30	0	0	W1



PCSTABL5M/SI FSmin = 1.02 X-Axis (ft)
Factors Of Safety Calculated By The Modified Bishop Method

262

ROCKY FLATS OLF - M&E C 18% GRD - WCS = 15 deg - W/AVEGW - CIRCULAR - 0.04g
All surfaces evaluated. C:CGAC04.PLT By: STAN KLINE 10-26-04 12:12am

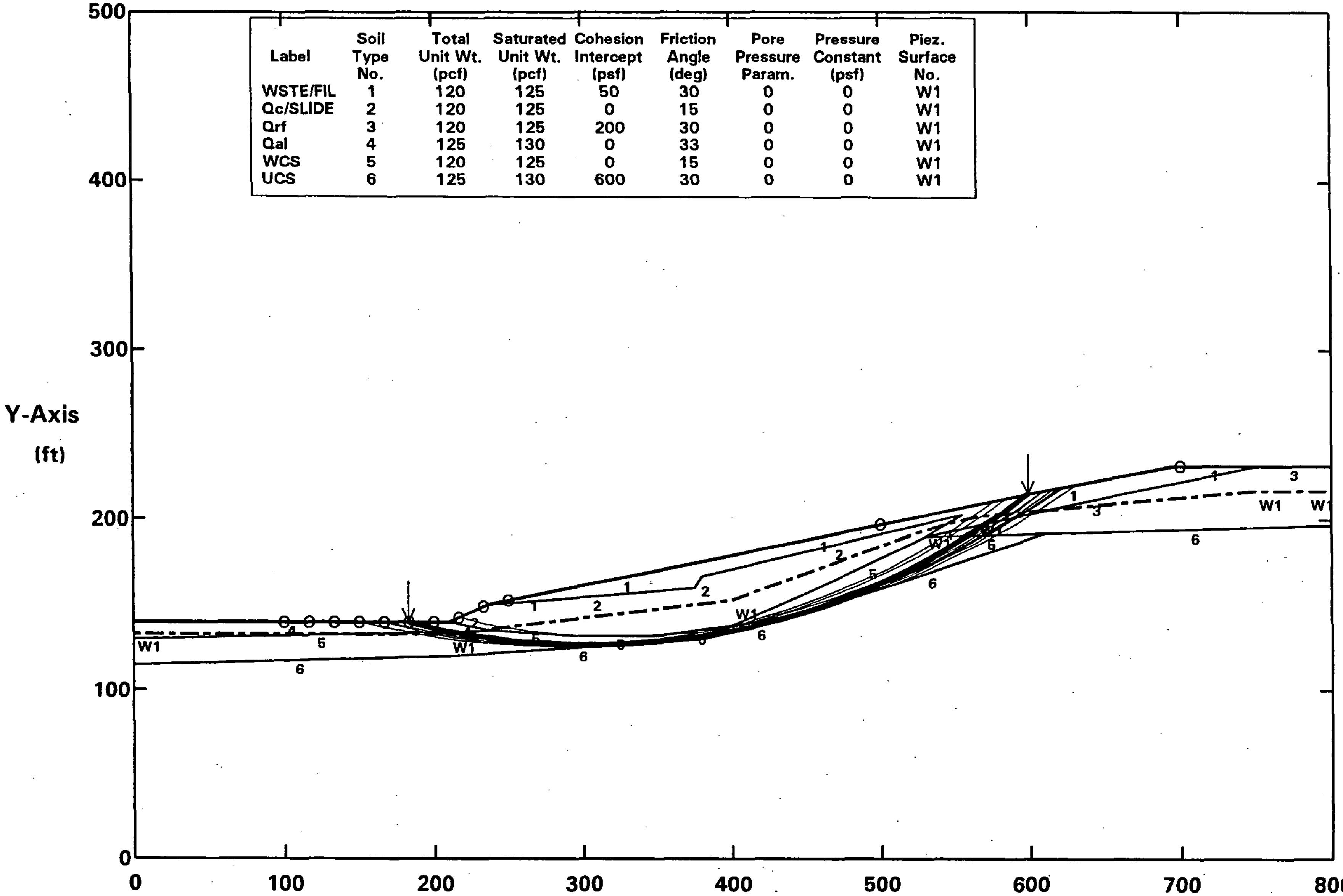


Factors Of Safety Calculated By The Modified Bishop Method

264

ROCKY FLATS OLF - M&E C 18% GRD - WCS=15 deg - W/AVEGW - CIRCULAR - 0.06g
Ten Most Critical. C:CGAC06.PLT By: STAN KLINE 10-26-04 12:12am

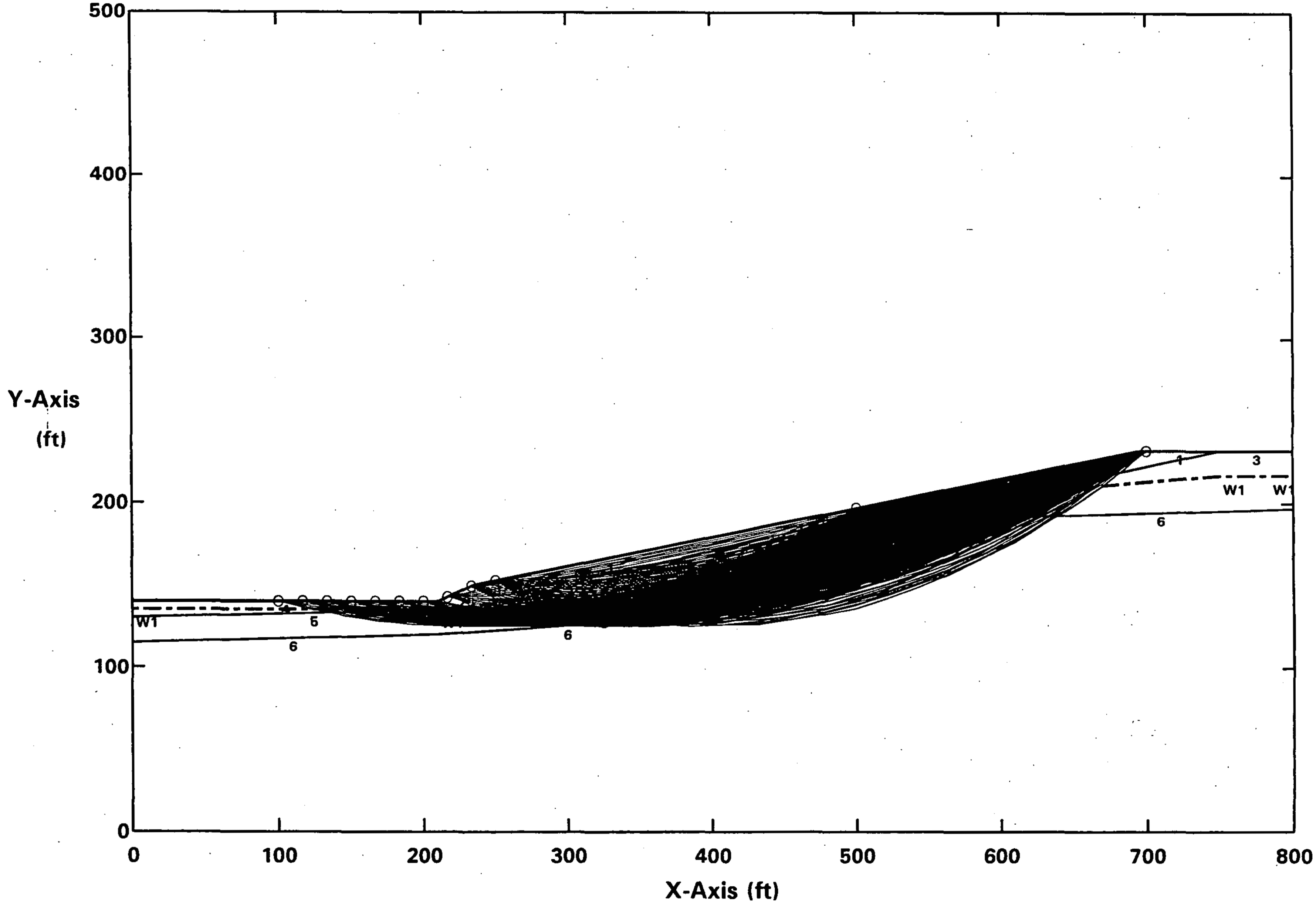
Label	Soil Type No.	Total Unit Wt. (pcf)	Saturated Unit Wt. (pcf)	Cohesion Intercept (psf)	Friction Angle (deg)	Pore Pressure Param.	Pressure Constant (psf)	Piez. Surface No.
WSTE/FIL	1	120	125	50	30	0	0	W1
Qc/SLIDE	2	120	125	0	15	0	0	W1
Qrf	3	120	125	200	30	0	0	W1
Qal	4	125	130	0	33	0	0	W1
WCS	5	120	125	0	15	0	0	W1
UCS	6	125	130	600	30	0	0	W1



PCSTABL5M/SI FSmin=0.93 X-Axis (ft)
Factors Of Safety Calculated By The Modified Bishop Method

262

ROCKY FLATS OLF - M&E C 18% GRD - WCS=15 deg - W/HIGHGW - CIRCULAR - 0.06g
All surfaces evaluated. C:CGHC06.PLT By: STAN KLINE 10-26-04 12:17am

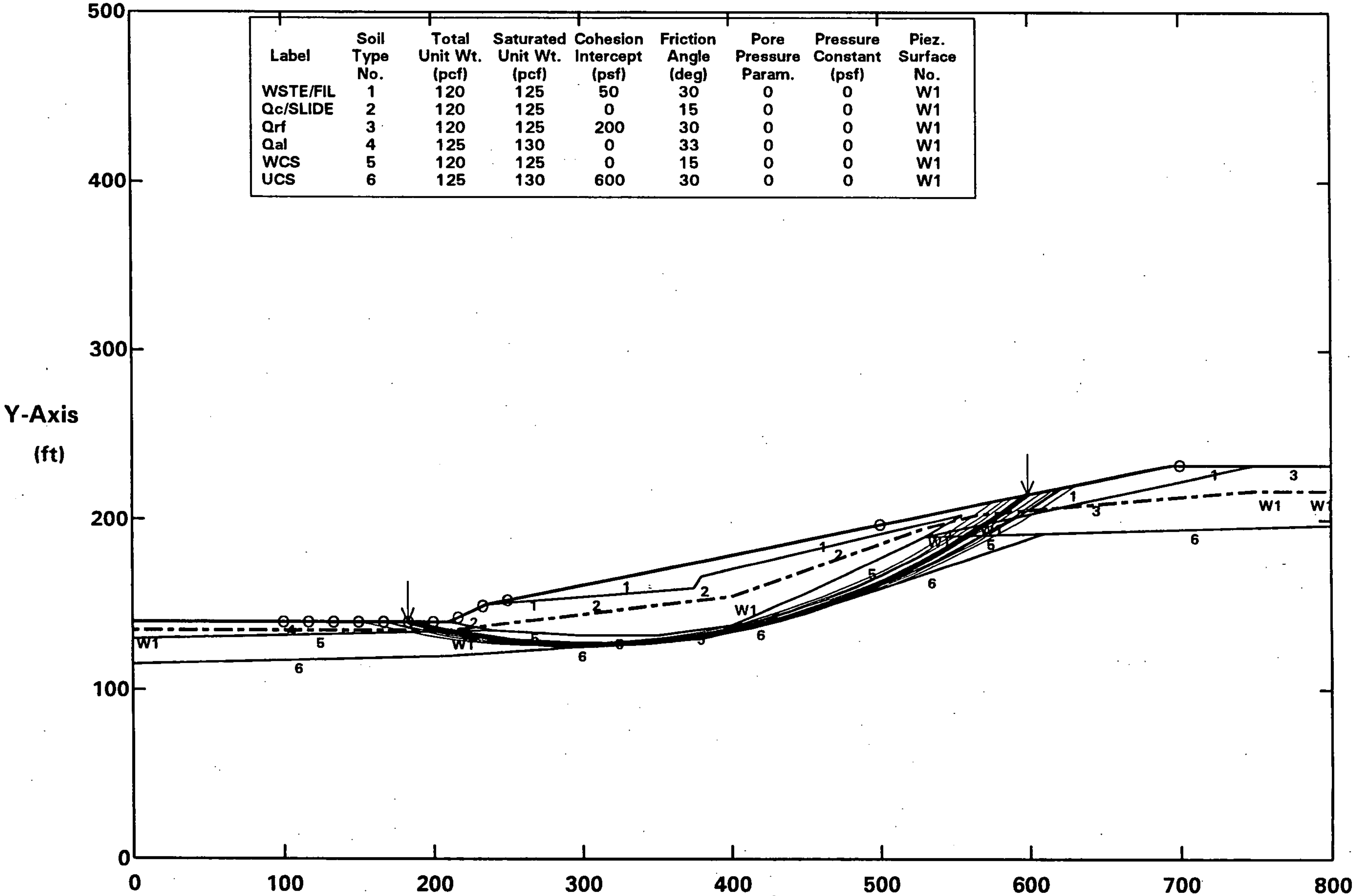


Factors Of Safety Calculated By The Modified Bishop Method

266

ROCKY FLATS OLF - M&E C 18% GRD - WCS=15 deg - W/HIGHGW - CIRCULAR - 0.06g
Ten Most Critical. C:CGHC06.PLT By: STAN KLINE 10-26-04 12:17am

Label	Soil Type No.	Total Unit Wt. (pcf)	Saturated Unit Wt. (pcf)	Cohesion Intercept (psf)	Friction Angle (deg)	Pore Pressure Param.	Pressure Constant (psf)	Piez. Surface No.
WSTE/FIL	1	120	125	50	30	0	0	W1
Qc/SLIDE	2	120	125	0	15	0	0	W1
Qrf	3	120	125	200	30	0	0	W1
Qal	4	125	130	0	33	0	0	W1
WCS	5	120	125	0	15	0	0	W1
UCS	6	125	130	600	30	0	0	W1

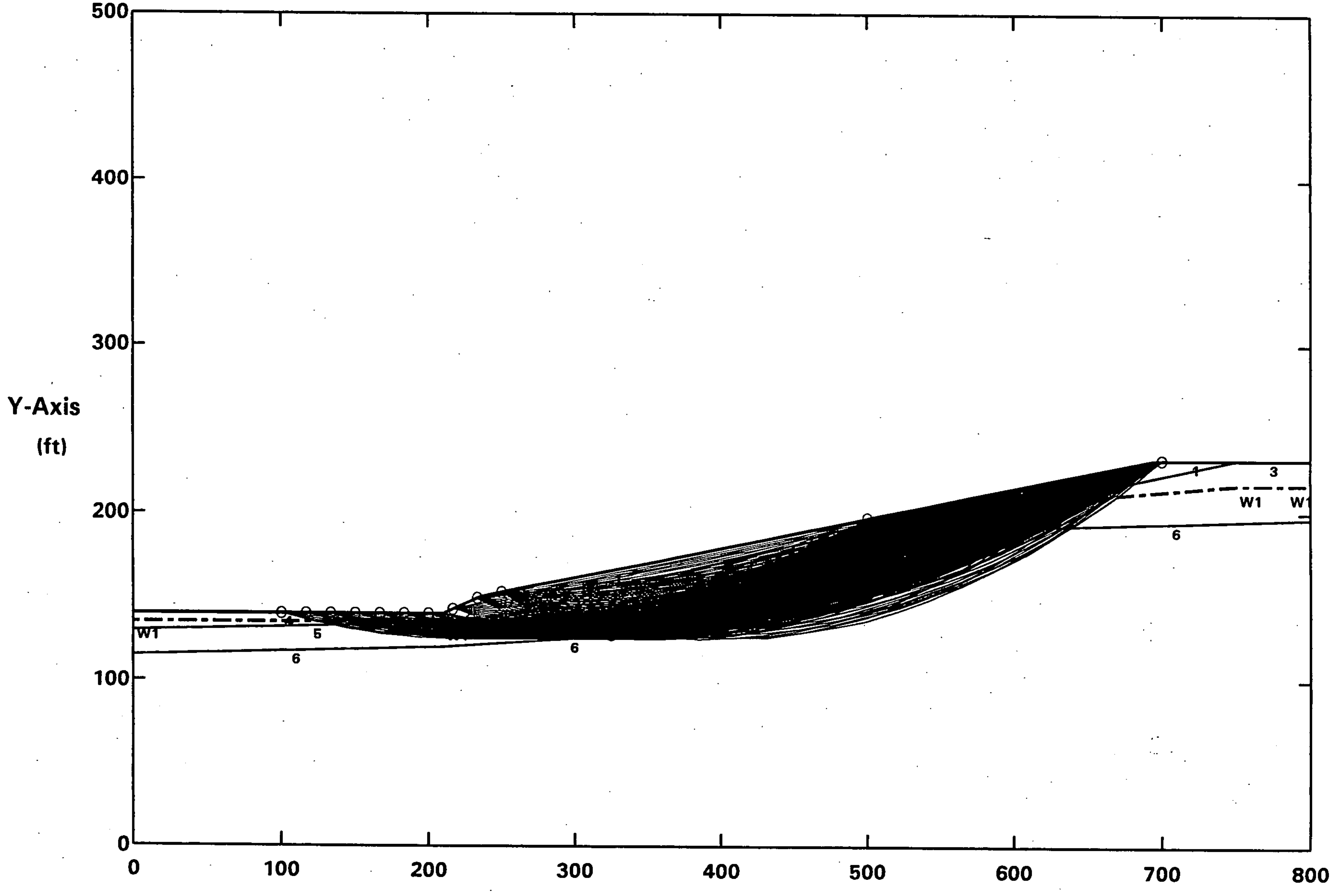


PCSTABL5M/SI FSmin=0.90 X-Axis (ft)

Factors Of Safety Calculated By The Modified Bishop Method

267

ROCKY FLATS OLF - M&E C 18% GRD - WCS = 15 deg - W/HIGHGW - CIRCULAR - 0.03g
All surfaces evaluated. C:CGHC03.PLT By: STAN KLINE 10-26-04 12:16am



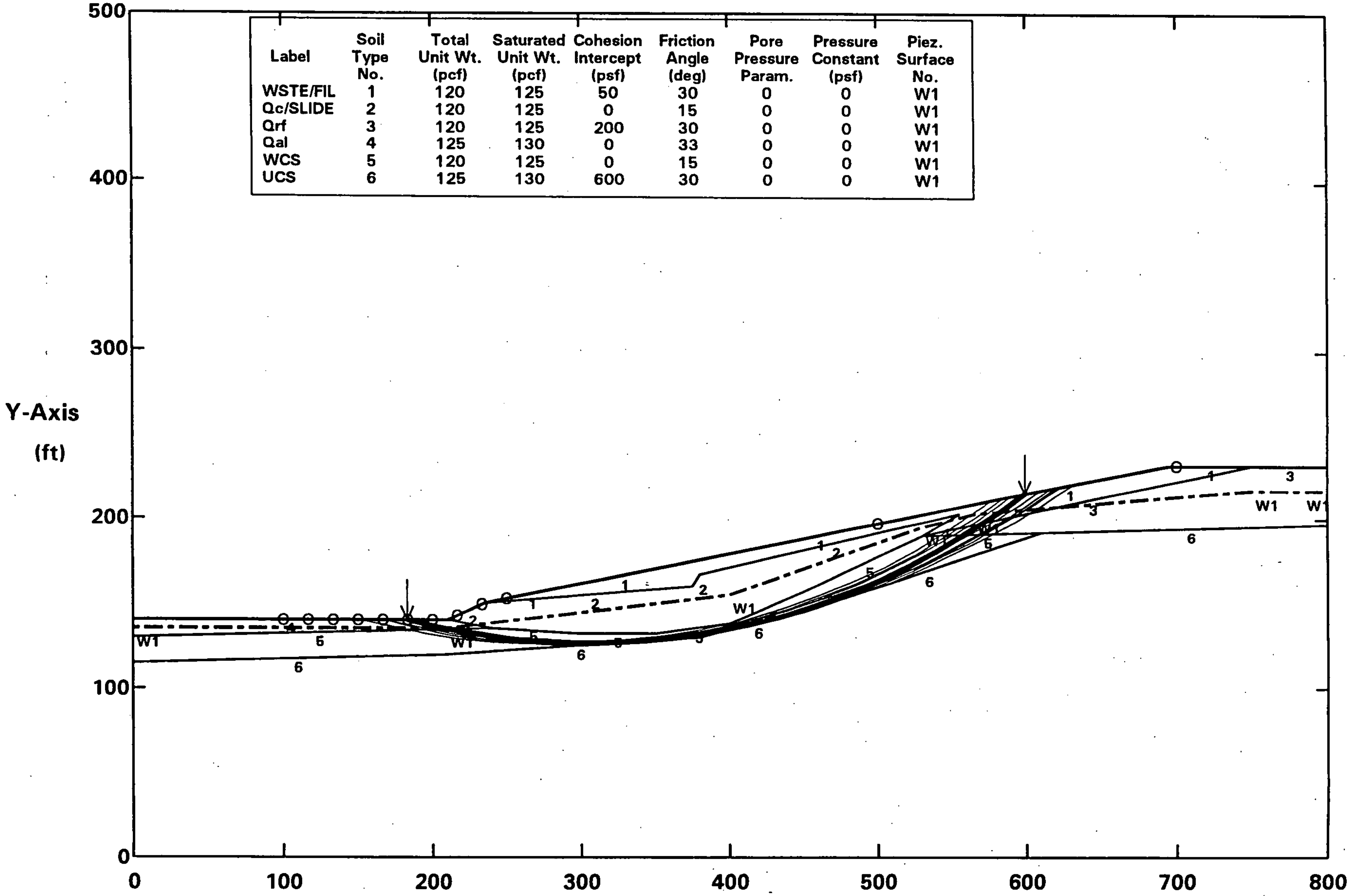
Factors Of Safety Calculated By The Modified Bishop Method

268

ROCKY FLATS OLF - M&E C 18% GRD - WCS = 15 deg - W/HIGHGW - CIRCULAR - 0.03g

Ten Most Critical. C:CGHC03.PLT By: STAN KLINE 10-26-04 12:16am

Label	Soil Type No.	Total Unit Wt. (pcf)	Saturated Unit Wt. (pcf)	Cohesion Intercept (psf)	Friction Angle (deg)	Pore Pressure Param.	Pressure Constant (psf)	Piez. Surface No.
WSTE/FIL	1	120	125	50	30	0	0	W1
Qc/SLIDE	2	120	125	0	15	0	0	W1
Qrf	3	120	125	200	30	0	0	W1
Qal	4	125	130	0	33	0	0	W1
WCS	5	120	125	0	15	0	0	W1
UCS	6	125	130	600	30	0	0	W1

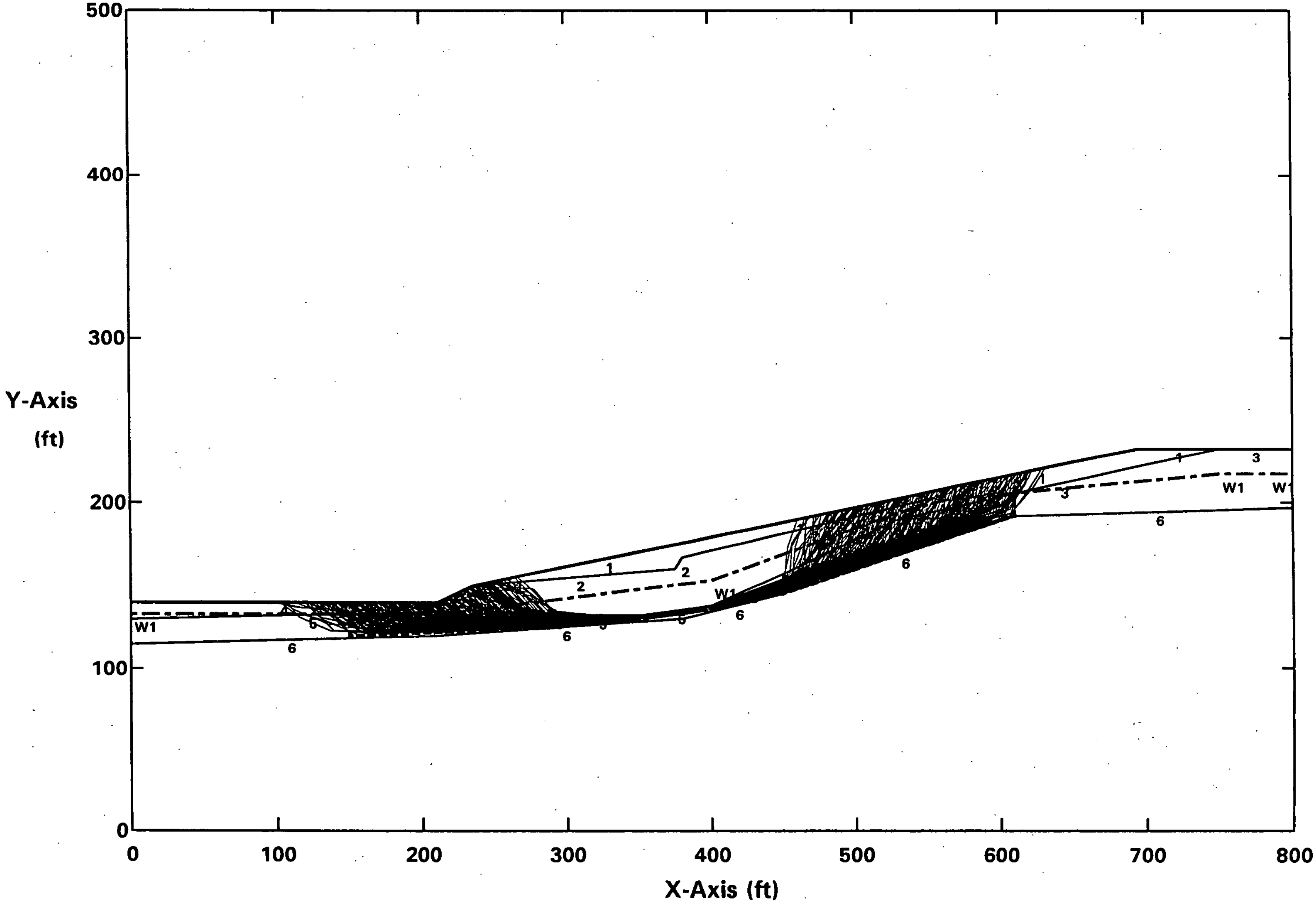


PCSTABL5M/SI FSmin = 1.04 X-Axis (ft)

Factors Of Safety Calculated By The Modified Bishop Method

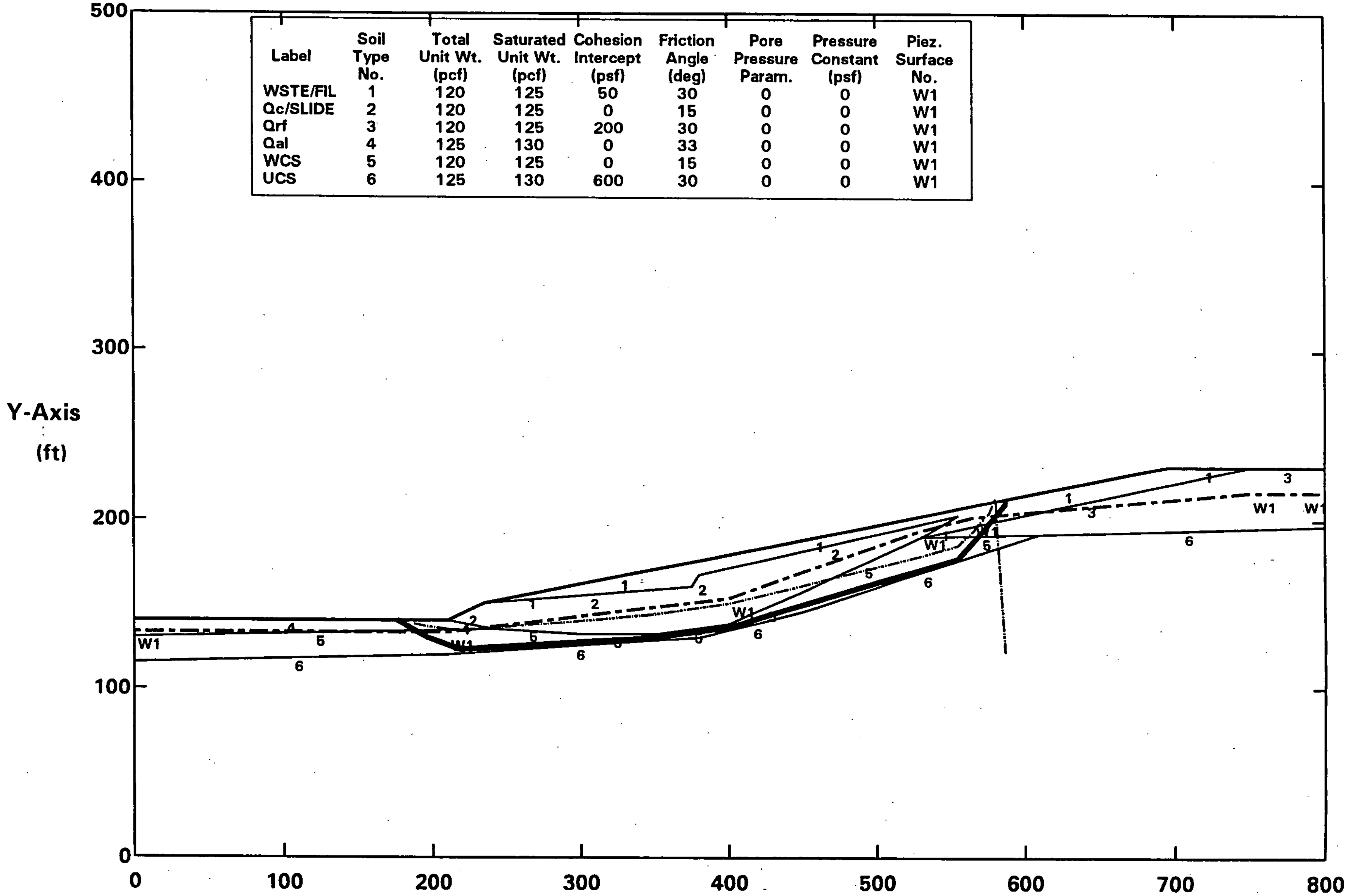
264

ROCKY FLATS OLF - M&E C 18% GRD - WCS = 15 deg - W/AVEGW - SLIDING BLOCK - 0.06g
All surfaces evaluated. C:CGAS06.PLT By: STAN KLINE 10-24-04 7:01pm



Factors Of Safety Calculated By The Modified Janbu Method

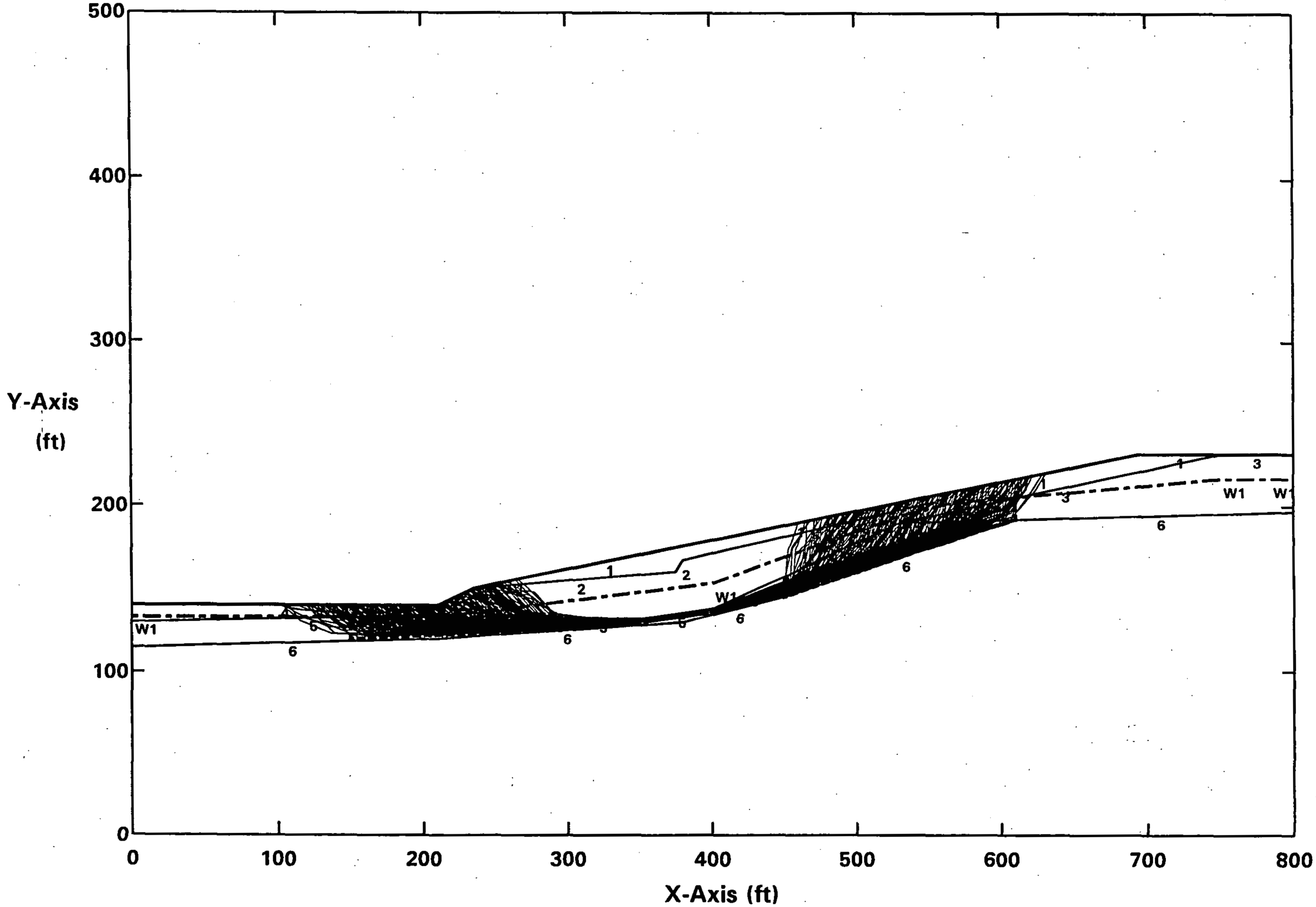
ROCKY FLATS OLF - M&E C 18% GRD - WCS = 15 deg - W/AVEGW - SLIDING BLOCK - 0.06g
Surface #1-CGAS06.OUT. C:CGAS06SP.PLT By: STAN KLINE 10-24-04 7:03pm



Label	Soil Type No.	Total Unit Wt. (pcf)	Saturated Unit Wt. (pcf)	Cohesion Intercept (psf)	Friction Angle (deg)	Pore Pressure Param.	Pressure Constant (psf)	Piez. Surface No.
WSTE/FIL	1	120	125	50	30	0	0	W1
Qc/SLIDE	2	120	125	0	15	0	0	W1
Qrf	3	120	125	200	30	0	0	W1
Qal	4	125	130	0	33	0	0	W1
WCS	5	120	125	0	15	0	0	W1
UCS	6	125	130	600	30	0	0	W1

PCSTABL5M/SI FS = 0.91 Theta = 8.85 X-Axis (ft)
Factors Of Safety Calculated By Spencer`s Method of Slices

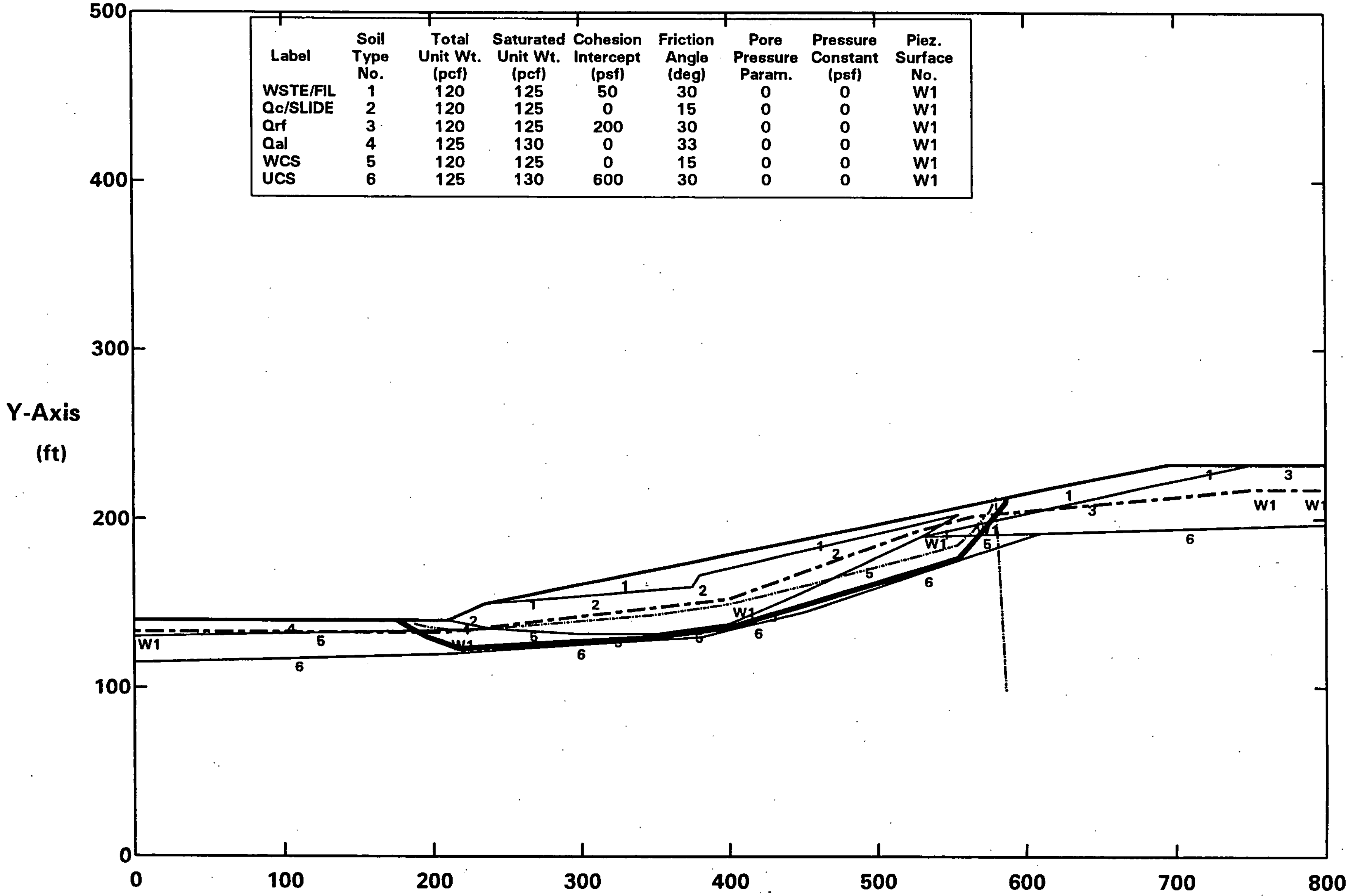
ROCKY FLATS OLF - M&E C 18% GRD - WCS = 15 deg - W/AVEGW - SLIDING BLOCK - 0.04g
All surfaces evaluated. C:CGAS04.PLT By: STAN KLINE 10-24-04 6:58pm



Factors Of Safety Calculated By The Modified Janbu Method

272

ROCKY FLATS OLF - M&E C 18% GRD - WCS = 15 deg - W/AVEGW - SLIDING BLOCK - 0.04g
Surface #1-CGAS04.OUT. C:CGAS04SP.PLT By: STAN KLINE 10-24-04 7:00pm

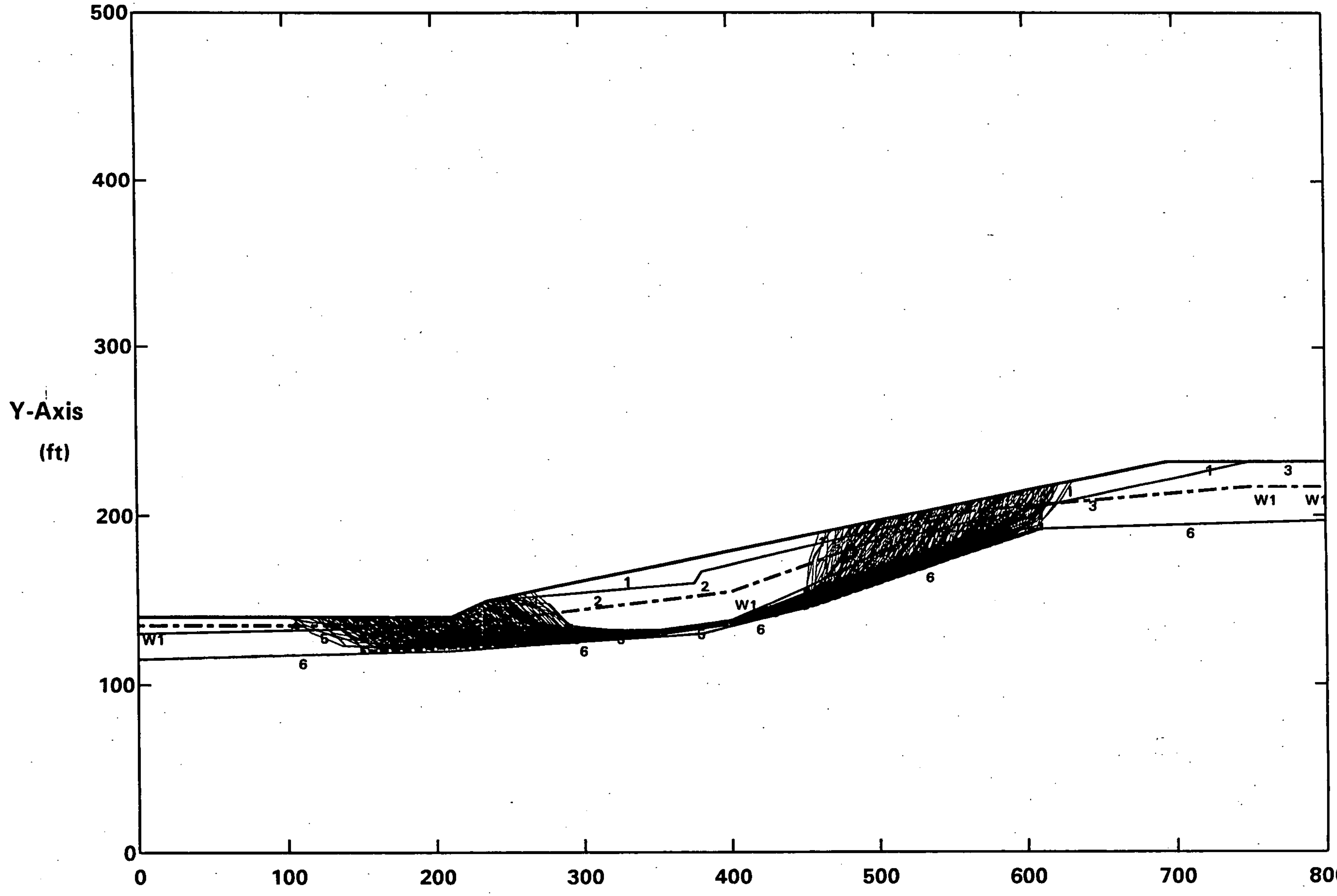


Label	Soil Type No.	Total Unit Wt. (pcf)	Saturated Unit Wt. (pcf)	Cohesion Intercept (psf)	Friction Angle (deg)	Pore Pressure Param.	Pressure Constant (psf)	Piez. Surface No.
WSTE/FIL	1	120	125	50	30	0	0	W1
Qc/SLIDE	2	120	125	0	15	0	0	W1
Qrf	3	120	125	200	30	0	0	W1
Qal	4	125	130	0	33	0	0	W1
WCS	5	120	125	0	15	0	0	W1
UCS	6	125	130	600	30	0	0	W1

PCSTABL5M/SI FS = 1.00 Theta = 8.96 X-Axis (ft)
Factors Of Safety Calculated By Spencer`s Method of Slices

273

ROCKY FLATS OLF - M&E C 18% GRD - WCS = 15 deg - W/HIGHGW - SLIDING BLOCK - 0.06g
All surfaces evaluated. C:CGHS06.PLT By: STAN KLINE 10-24-04 7:23pm

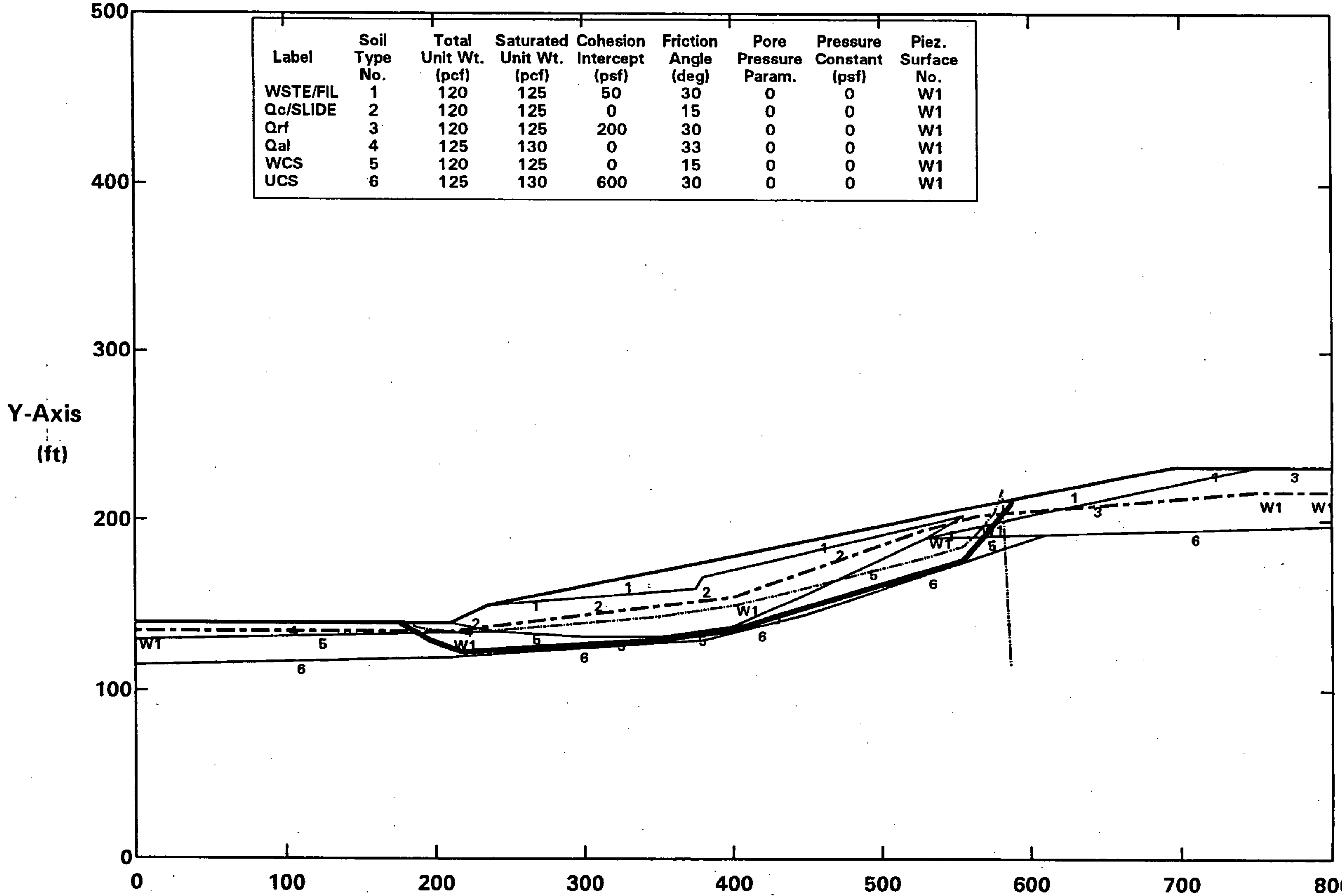


Factors Of Safety Calculated By The Modified Janbu Method

274

ROCKY FLATS OLF - M&E C 18% GRD - WCS=15 deg - W/HIGHGW - SLIDING BLOCK - 0.06g
Surface #1-CGHS06.OUT. C:CGHS06SP.PLT By: STAN KLINE 10-24-04 7:24pm

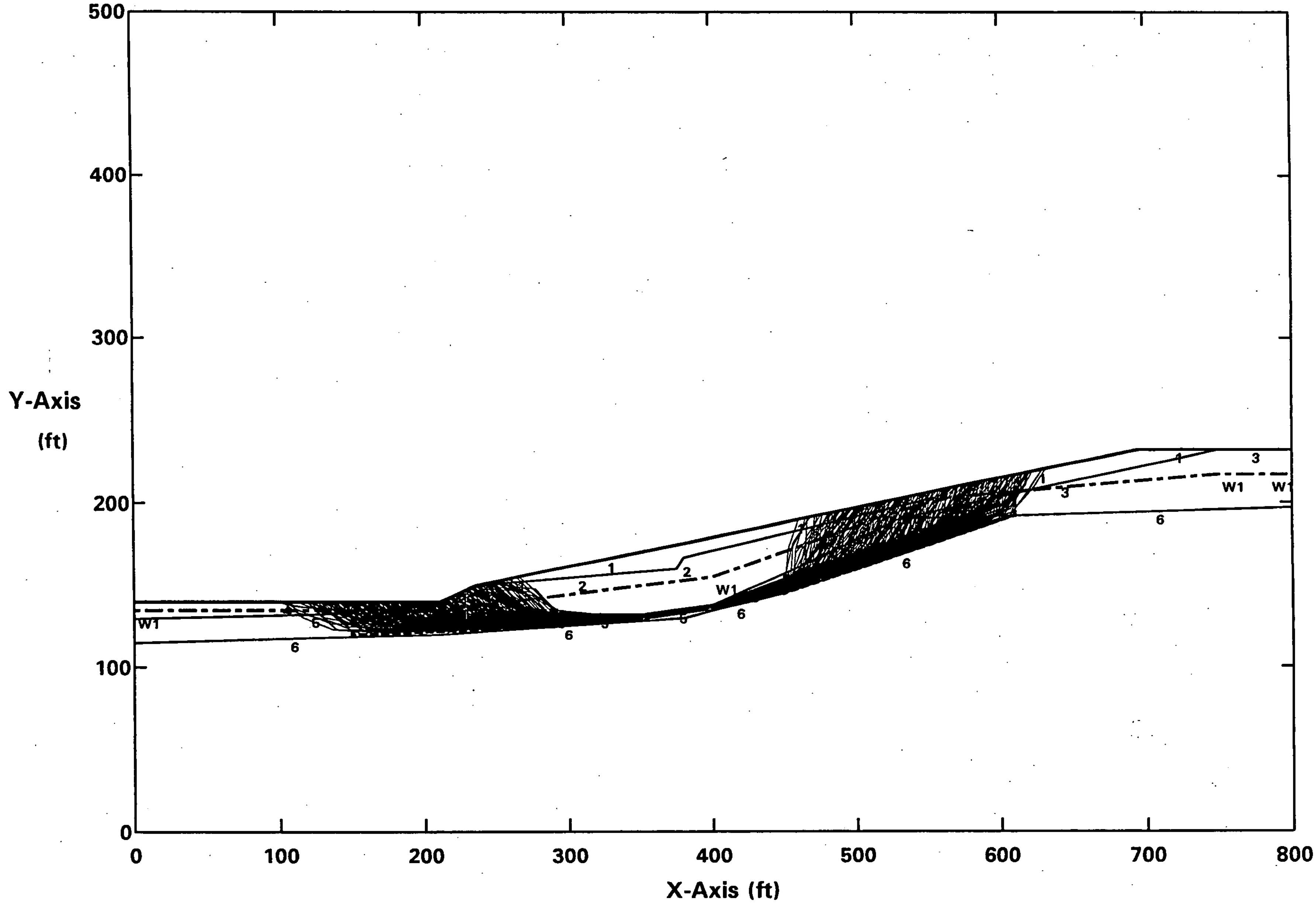
Label	Soil Type No.	Total Unit Wt. (pcf)	Saturated Unit Wt. (pcf)	Cohesion Intercept (psf)	Friction Angle (deg)	Pore Pressure Param.	Pressure Constant (psf)	Piez. Surface No.
WSTE/FIL	1	120	125	50	30	0	0	W1
Qc/SLIDE	2	120	125	0	15	0	0	W1
Qrf	3	120	125	200	30	0	0	W1
Qal	4	125	130	0	33	0	0	W1
WCS	5	120	125	0	15	0	0	W1
UCS	6	125	130	600	30	0	0	W1



PCSTABL5M/SI FS=0.88 Theta=8.87 X-Axis (ft)
Factors Of Safety Calculated By Spencer`s Method of Slices

275

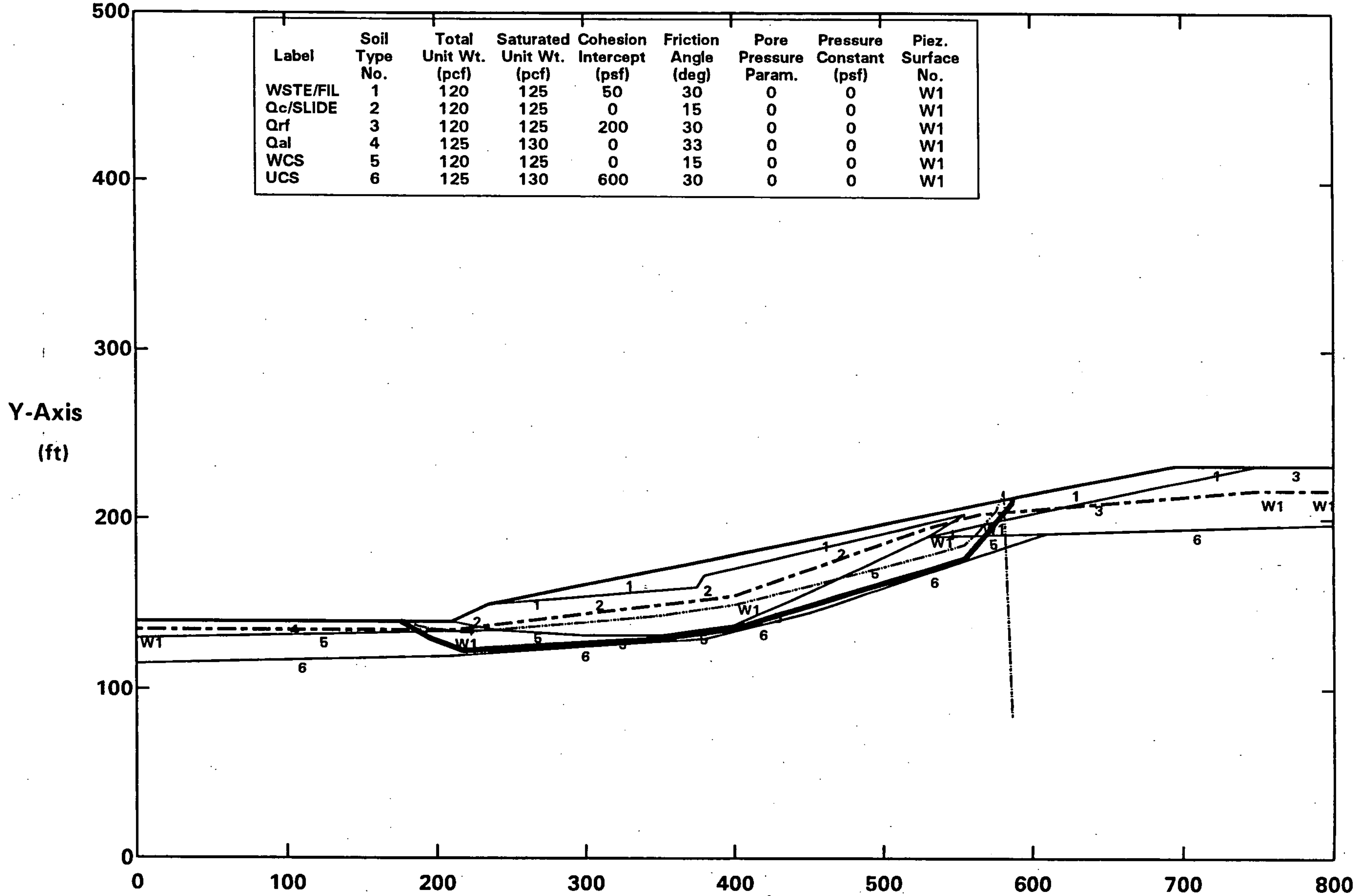
ROCKY FLATS OLF - M&E C 18% GRD - WCS = 15 deg - W/HIGHGW - SLIDING BLOCK - 0.03g
All surfaces evaluated. C:CGHS03.PLT By: STAN KLINE 10-24-04 7:20pm



Factors Of Safety Calculated By The Modified Janbu Method

276

ROCKY FLATS OLF - M&E C 18% GRD - WCS = 15 deg - W/HIGHGW - SLIDING BLOCK - 0.03g
Surface #1-CGHS03.OUT. C:CGHS03SP.PLT By: STAN KLINE 10-24-04 7:22pm



Label	Soil Type No.	Total Unit Wt. (pcf)	Saturated Unit Wt. (pcf)	Cohesion Intercept (psf)	Friction Angle (deg)	Pore Pressure Param.	Pressure Constant (psf)	Piez. Surface No.
WSTE/FIL	1	120	125	50	30	0	0	W1
Qc/SLIDE	2	120	125	0	15	0	0	W1
Qrf	3	120	125	200	30	0	0	W1
Qal	4	125	130	0	33	0	0	W1
WCS	5	120	125	0	15	0	0	W1
UCS	6	125	130	600	30	0	0	W1

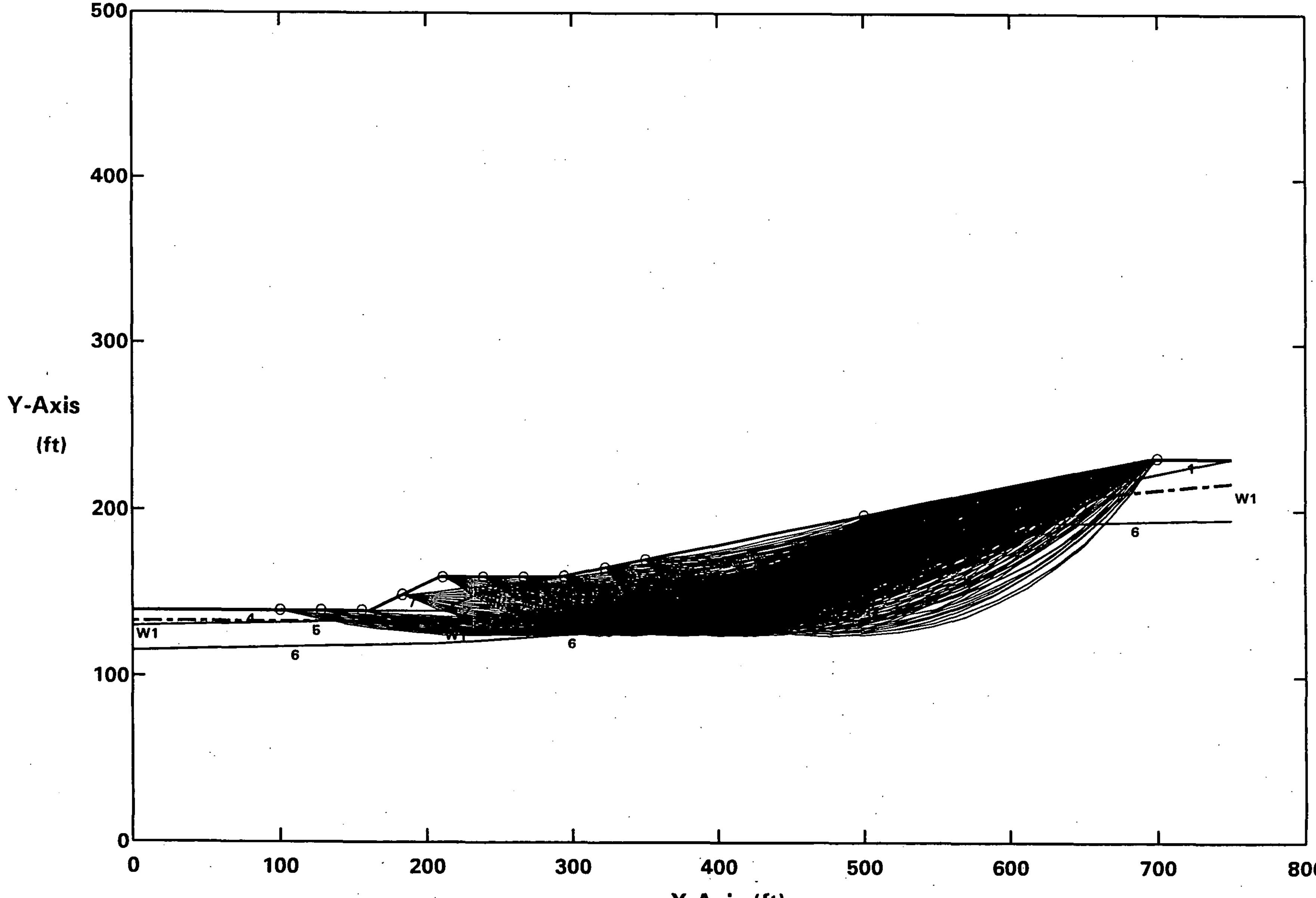
PCSTABL5M/SI FS = 1.01 Theta = 9.05 X-Axis (ft)
Factors Of Safety Calculated By Spencer`s Method of Slices

18% REGRADE WITH BUTTRESS CONDITION

277

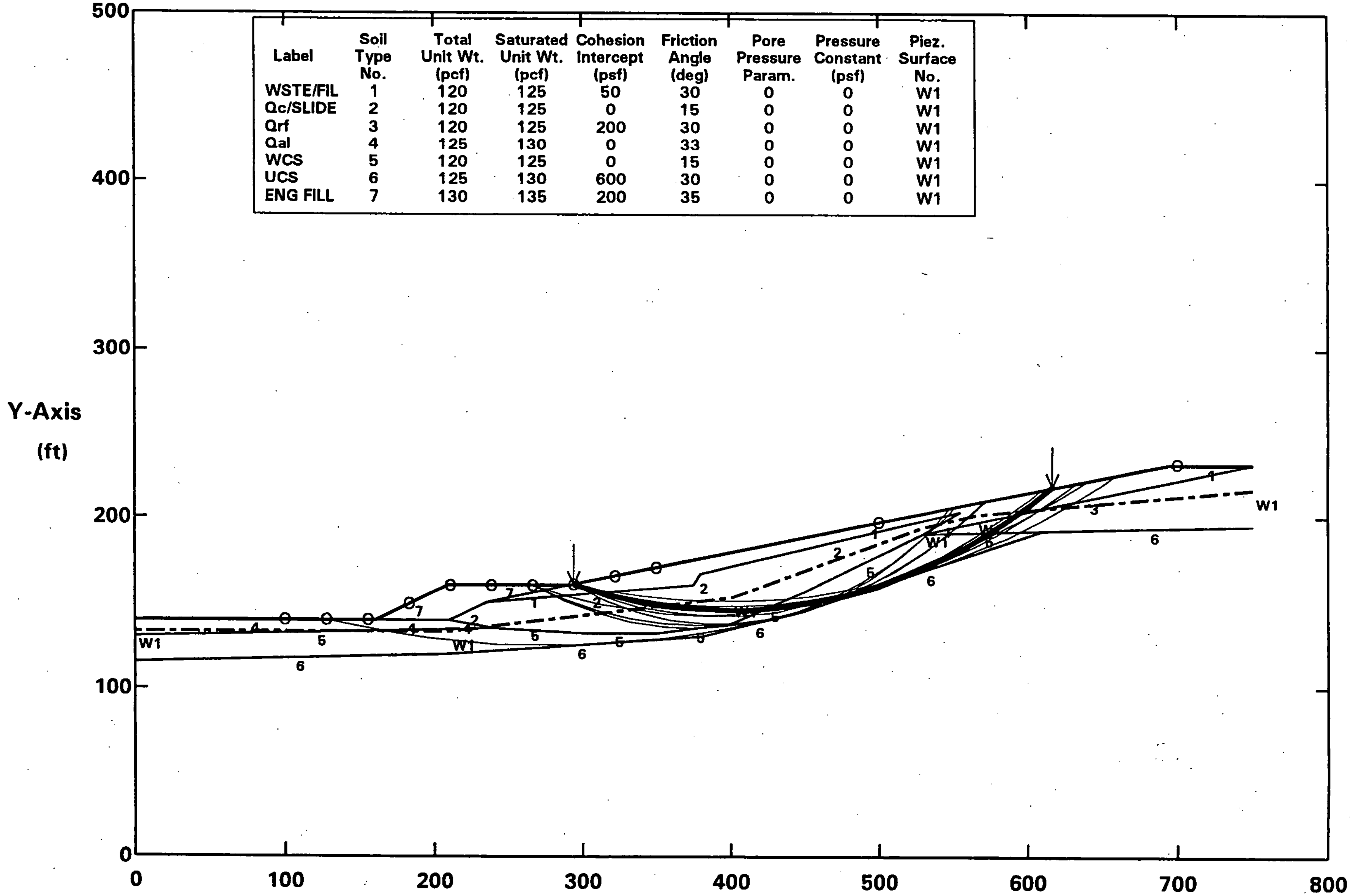
278

ROCKY FLATS OLF - M&E C 18%W/BM - WCS = 15 deg - W/AVEGW - CIRCULAR - 0.06g
All surfaces evaluated. C:CBAC06.PLT By: STAN KLINE 10-26-04 12:13am



Factors Of Safety Calculated By The Modified Bishop Method

ROCKY FLATS OLF - M&E C 18%W/BM - WCS = 15 deg - W/AVEGW - CIRCULAR - 0.06g
Ten Most Critical. C:CBAC06.PLT By: STAN KLINE 10-26-04 12:13am

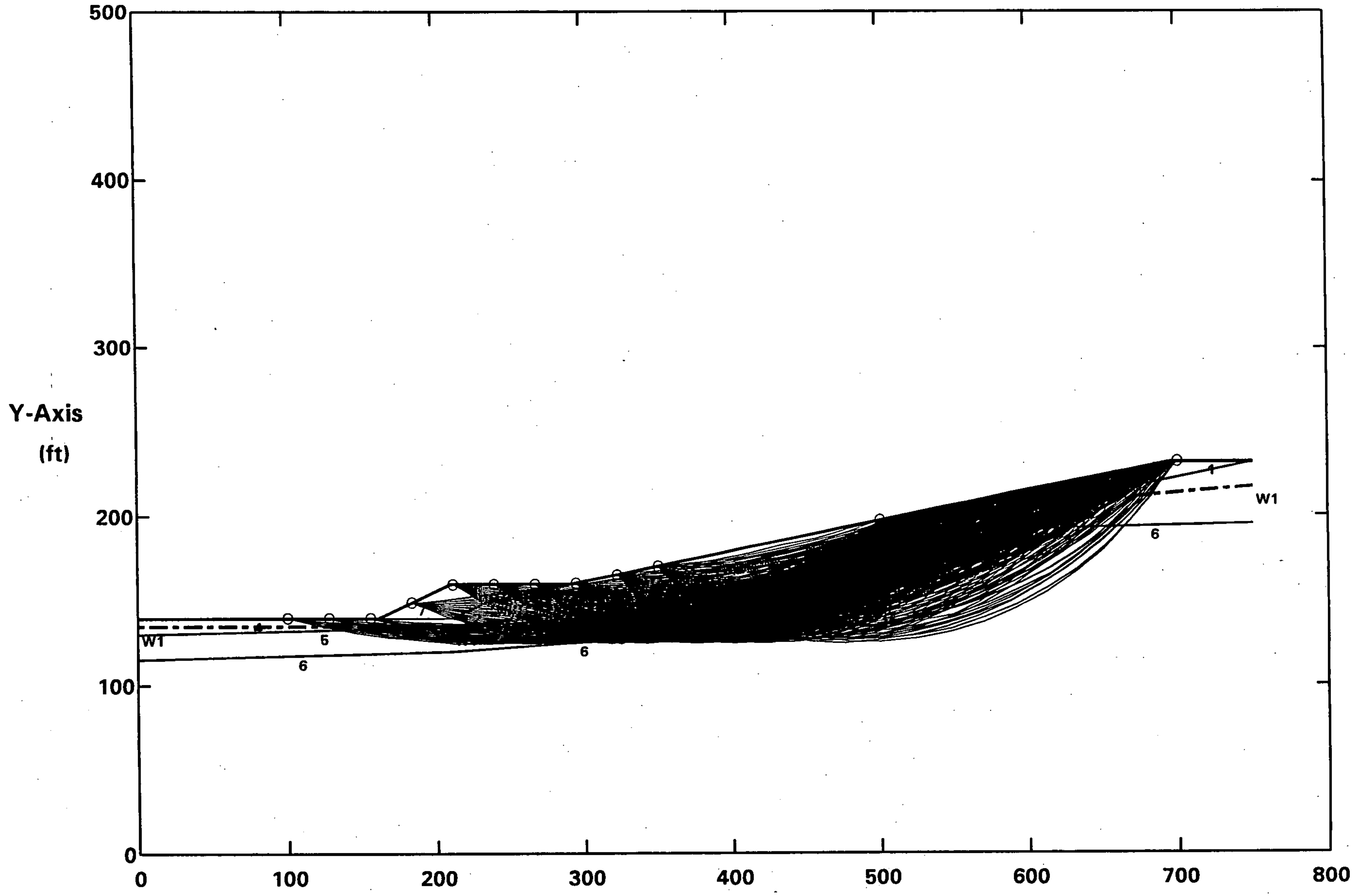


Label	Soil Type No.	Total Unit Wt. (pcf)	Saturated Unit Wt. (pcf)	Cohesion Intercept (psf)	Friction Angle (deg)	Pore Pressure Param.	Pressure Constant (psf)	Piez. Surface No.
WSTE/FIL	1	120	125	50	30	0	0	W1
Qc/SLIDE	2	120	125	0	15	0	0	W1
Qrf	3	120	125	200	30	0	0	W1
Qal	4	125	130	0	33	0	0	W1
WCS	5	120	125	0	15	0	0	W1
UCS	6	125	130	600	30	0	0	W1
ENG FILL	7	130	135	200	35	0	0	W1

PCSTABL5M/SI FSmin = 1.03 X-Axis (ft)
Factors Of Safety Calculated By The Modified Bishop Method

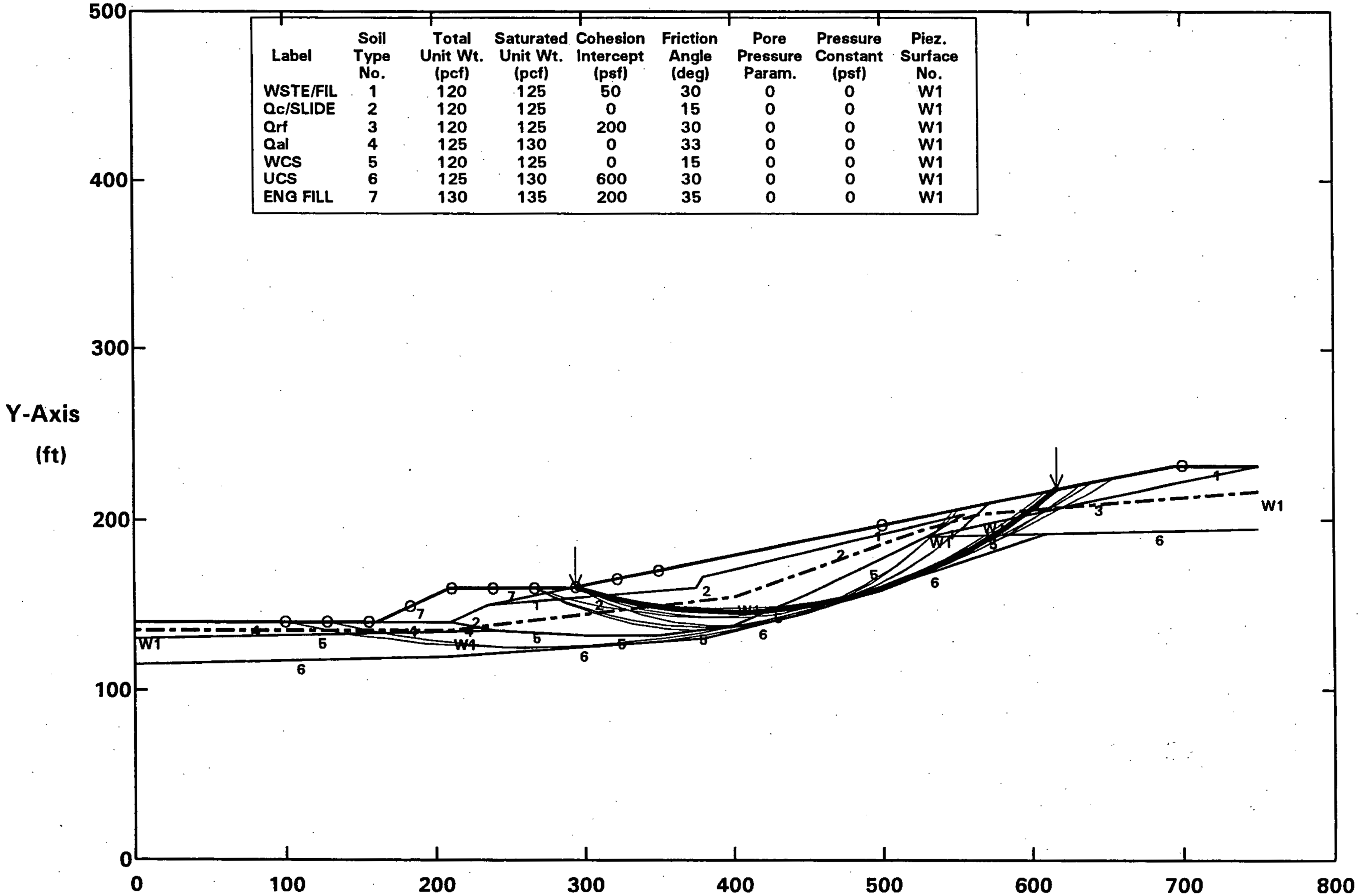
280

ROCKY FLATS OLF - M&E C 18%W/BM - WCS=15 deg - W/HIGHGW - CIRCULAR - 0.06g
All surfaces evaluated. C:CBHC06.PLT By: STAN KLINE 10-26-04 12:17am



Factors Of Safety Calculated By The Modified Bishop Method

ROCKY FLATS OLF - M&E C 18%W/BM - WCS=15 deg - W/HIGHGW - CIRCULAR - 0.06g
Ten Most Critical. C:CBHC06.PLT By: STAN KLINE 10-26-04 12:17am

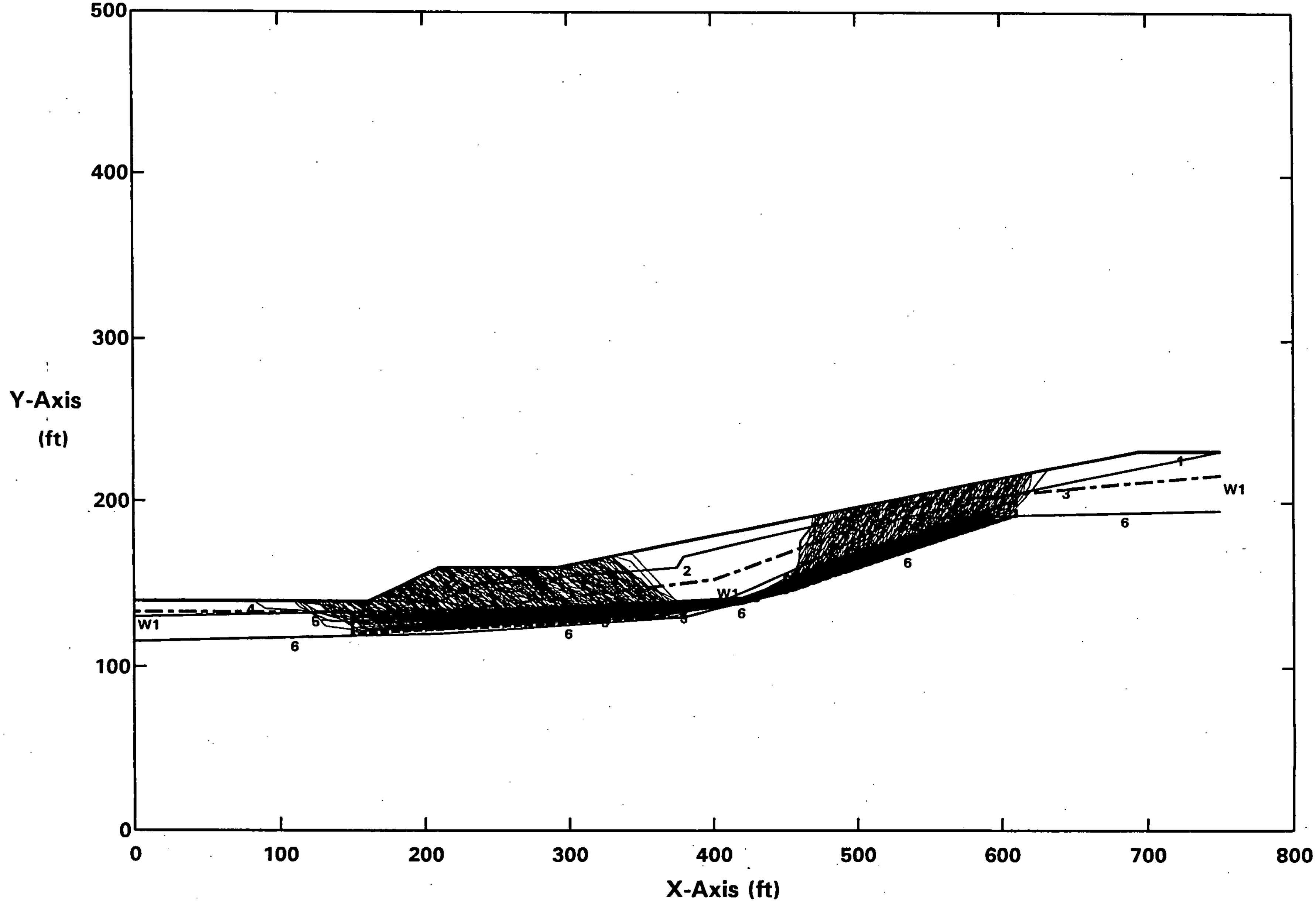


Label	Soil Type No.	Total Unit Wt. (pcf)	Saturated Unit Wt. (pcf)	Cohesion Intercept (psf)	Friction Angle (deg)	Pore Pressure Param.	Pressure Constant (psf)	Piez. Surface No.
WSTE/FIL	1	120	125	50	30	0	0	W1
Qc/SLIDE	2	120	125	0	15	0	0	W1
Qrf	3	120	125	200	30	0	0	W1
Qal	4	125	130	0	33	0	0	W1
WCS	5	120	125	0	15	0	0	W1
UCS	6	125	130	600	30	0	0	W1
ENG FILL	7	130	135	200	35	0	0	W1

PCSTABL5M/SI FSmin=1.01 X-Axis (ft)
Factors Of Safety Calculated By The Modified Bishop Method

282

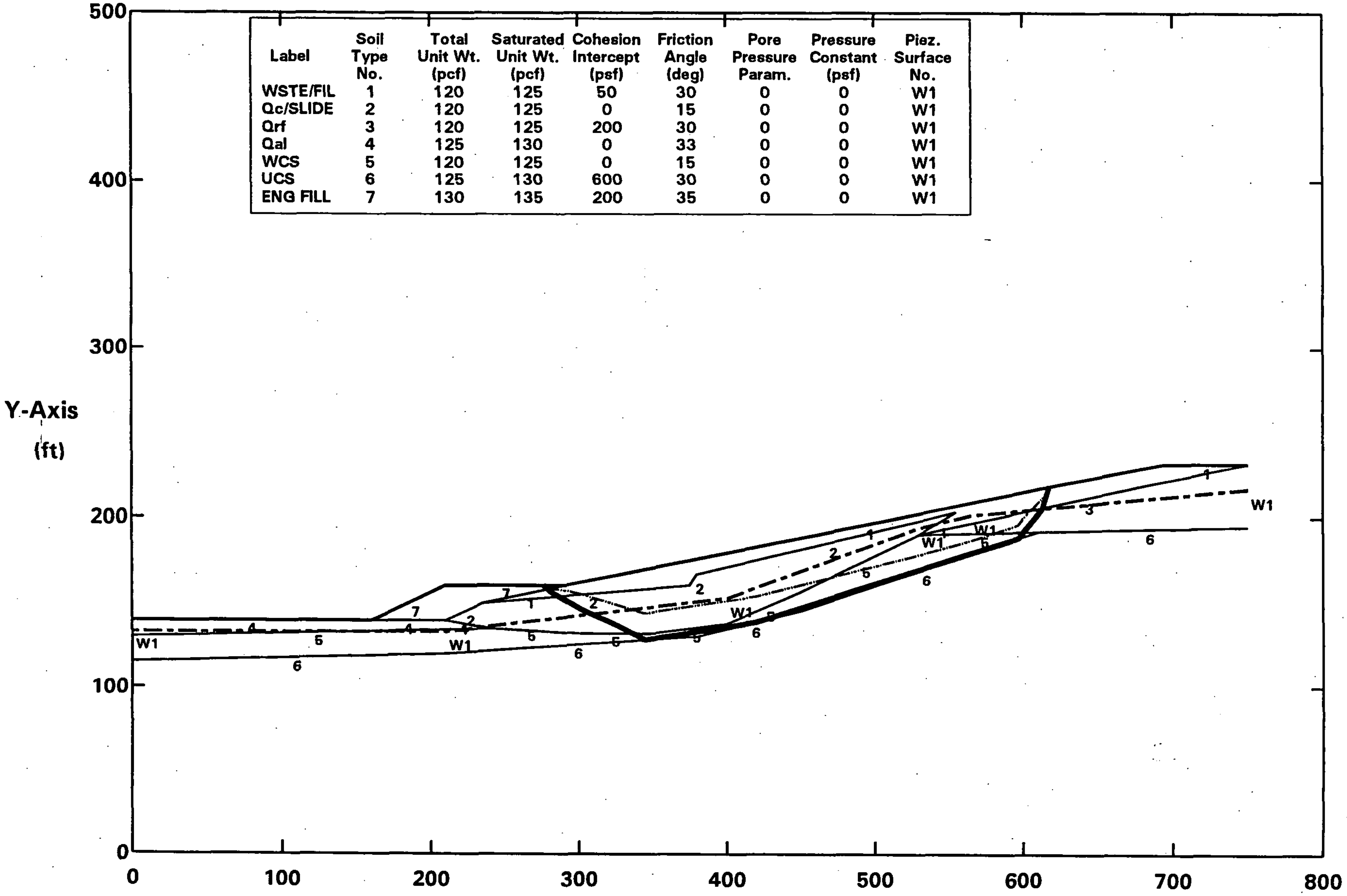
ROCKY FLATS OLF - M&E C 18%W/BM - WCS = 15 deg - W/AVEGW - SLIDING BLOCK - 0.06g
All surfaces evaluated. C:CBAS06.PLT By: STAN KLINE 10-24-04 7:05pm



Factors Of Safety Calculated By The Modified Janbu Method

283

ROCKY FLATS OLF - M&E C 18%W/BM - WCS = 15 deg - W/AVEGW - SLIDING BLOCK - 0.06g
Surface #1-CBAS06.OUT. C:CBAS06SP.PLT By: STAN KLINE 10-24-04 7:08pm

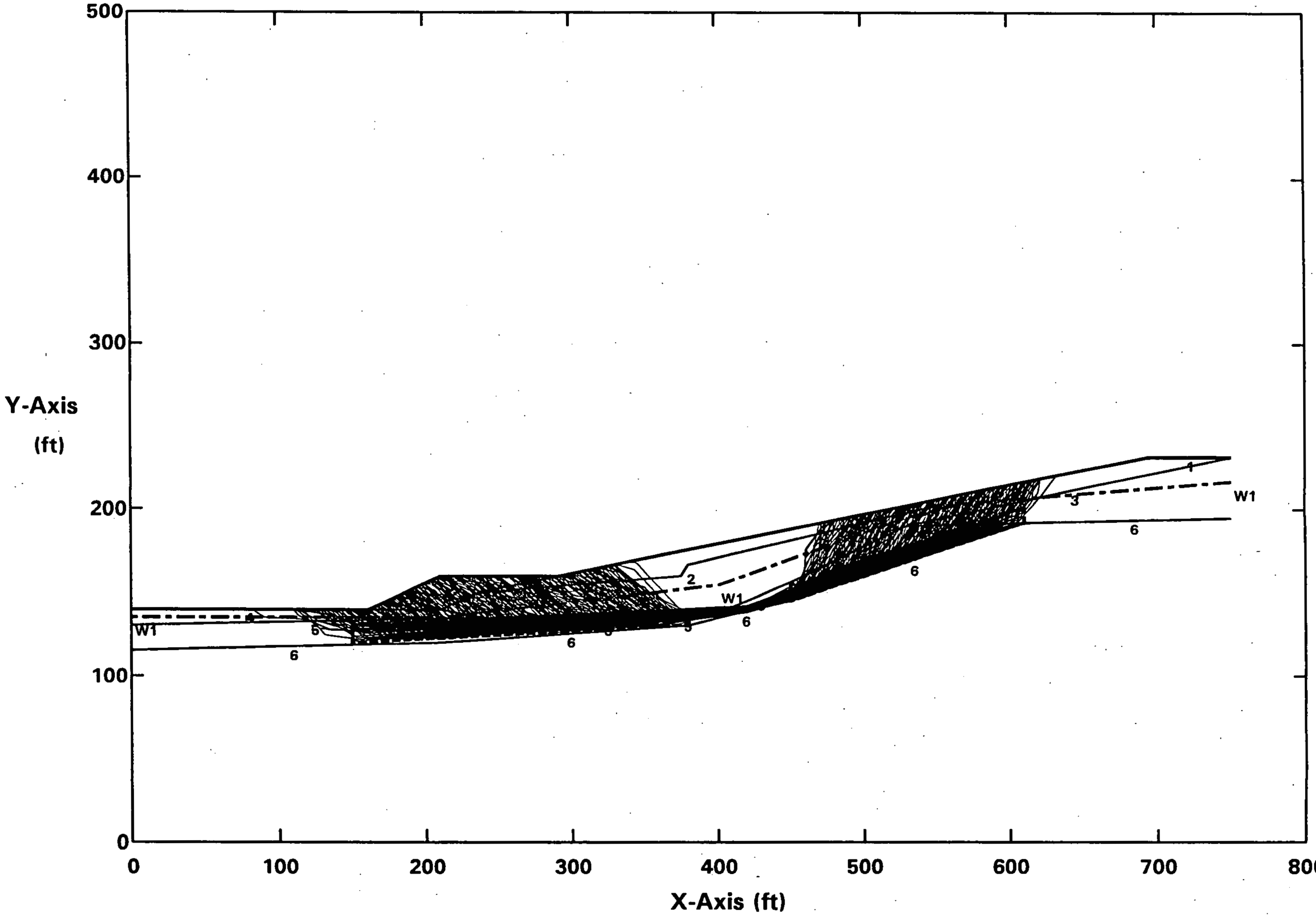


Label	Soil Type No.	Total Unit Wt. (pcf)	Saturated Unit Wt. (pcf)	Cohesion Intercept (psf)	Friction Angle (deg)	Pore Pressure Param.	Pressure Constant (psf)	Piez. Surface No.
WSTE/FIL	1	120	125	50	30	0	0	W1
Qc/SLIDE	2	120	125	0	15	0	0	W1
Qrf	3	120	125	200	30	0	0	W1
Qal	4	125	130	0	33	0	0	W1
WCS	5	120	125	0	15	0	0	W1
UCS	6	125	130	600	30	0	0	W1
ENG FILL	7	130	135	200	35	0	0	W1

PCSTABL5M/SI FS = 1.03 Theta = 7.72 X-Axis (ft)
Factors Of Safety Calculated By Spencer`s Method of Slices

284

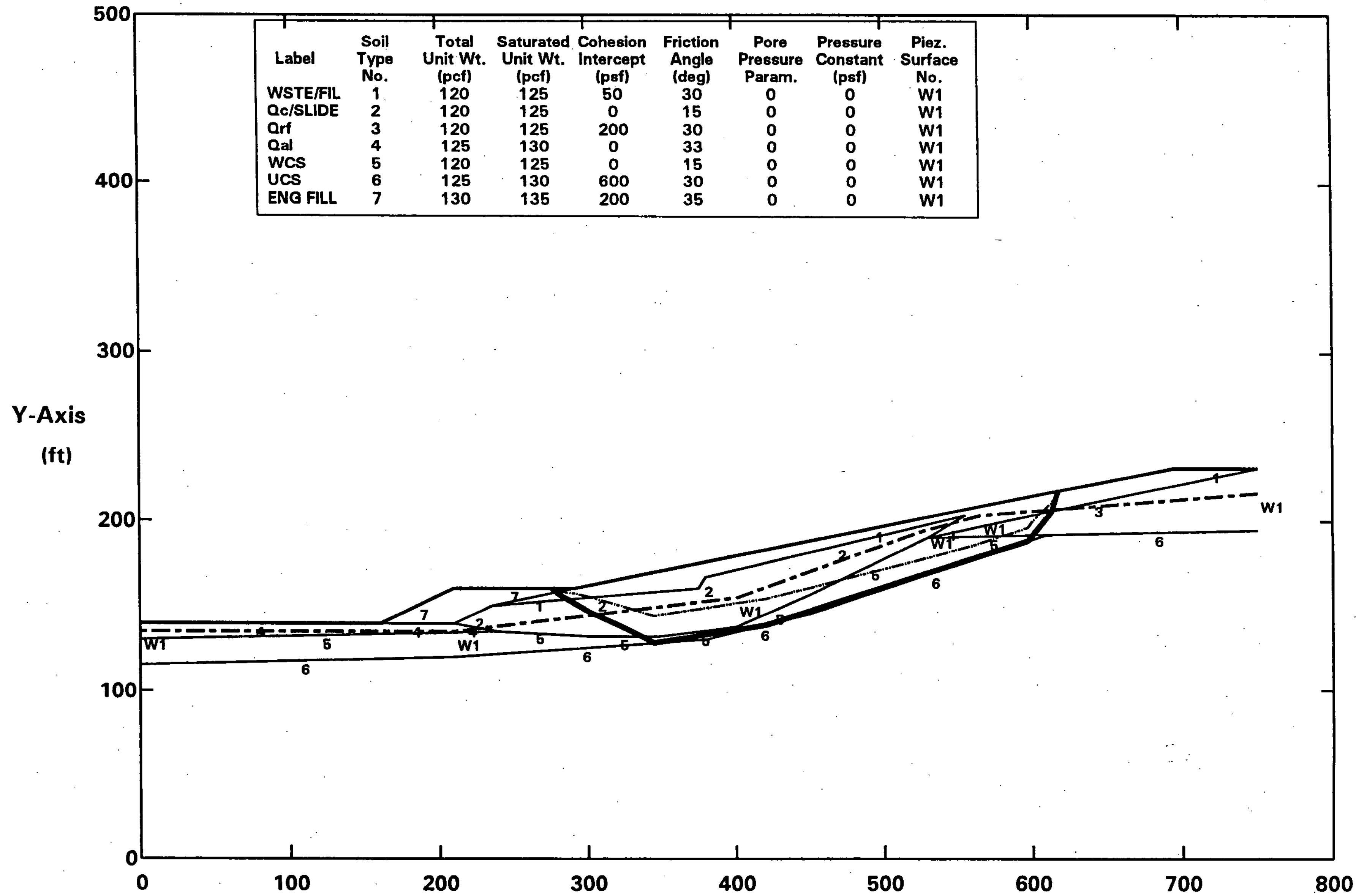
ROCKY FLATS OLF - M&E C 18%W/BM - WCS= 15 deg - W/HIGHGW - SLIDING BLOCK - 0.06g
All surfaces evaluated. C:CBHS06.PLT By: STAN KLINE 10-24-04 7:26pm



Factors Of Safety Calculated By The Modified Janbu Method

ROCKY FLATS OLF - M&E C 18%W/BM - WCS = 15 deg - W/HIGHGW - SLIDING BLOCK - 0.06g
Surface #1-CBHS06.OUT. C:CBHS06SP.PLT By: STAN KLINE 10-24-04 7:28pm

Label	Soil Type No.	Total Unit Wt. (pcf)	Saturated Unit Wt. (pcf)	Cohesion Intercept (psf)	Friction Angle (deg)	Pore Pressure Param.	Pressure Constant (psf)	Piez. Surface No.
WSTE/FIL	1	120	125	50	30	0	0	W1
Qc/SLIDE	2	120	125	0	15	0	0	W1
Qrf	3	120	125	200	30	0	0	W1
Qal	4	125	130	0	33	0	0	W1
WCS	5	120	125	0	15	0	0	W1
UCS	6	125	130	600	30	0	0	W1
ENG FILL	7	130	135	200	35	0	0	W1



PCSTABL5M/SI FS = 1.01 Theta = 7.66 X-Axis (ft)
Factors Of Safety Calculated By Spencer`s Method of Slices

M&E SECTION D-D' – PSEUDOSTATIC

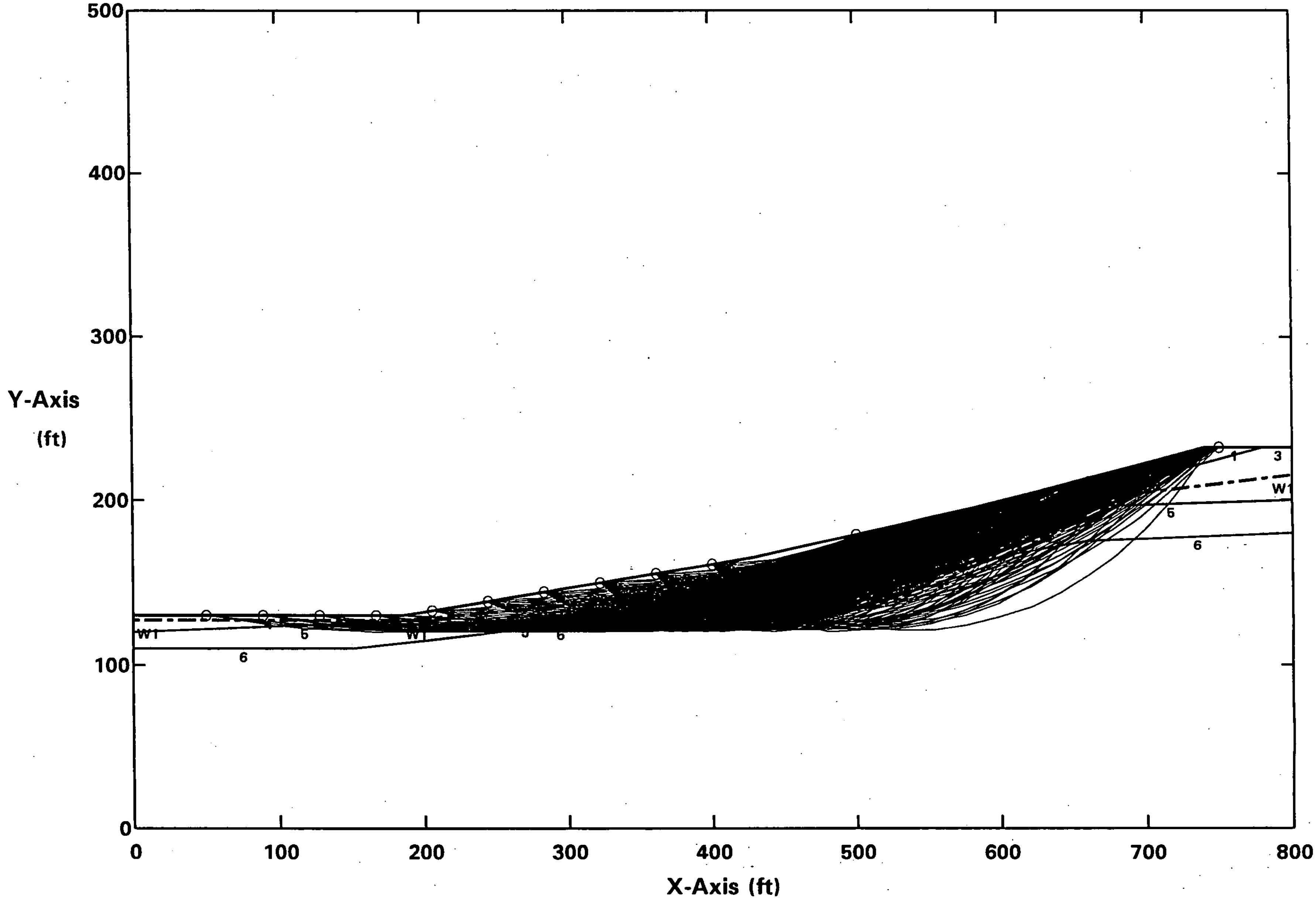
286

EXISTING CONDITIONS

287

288

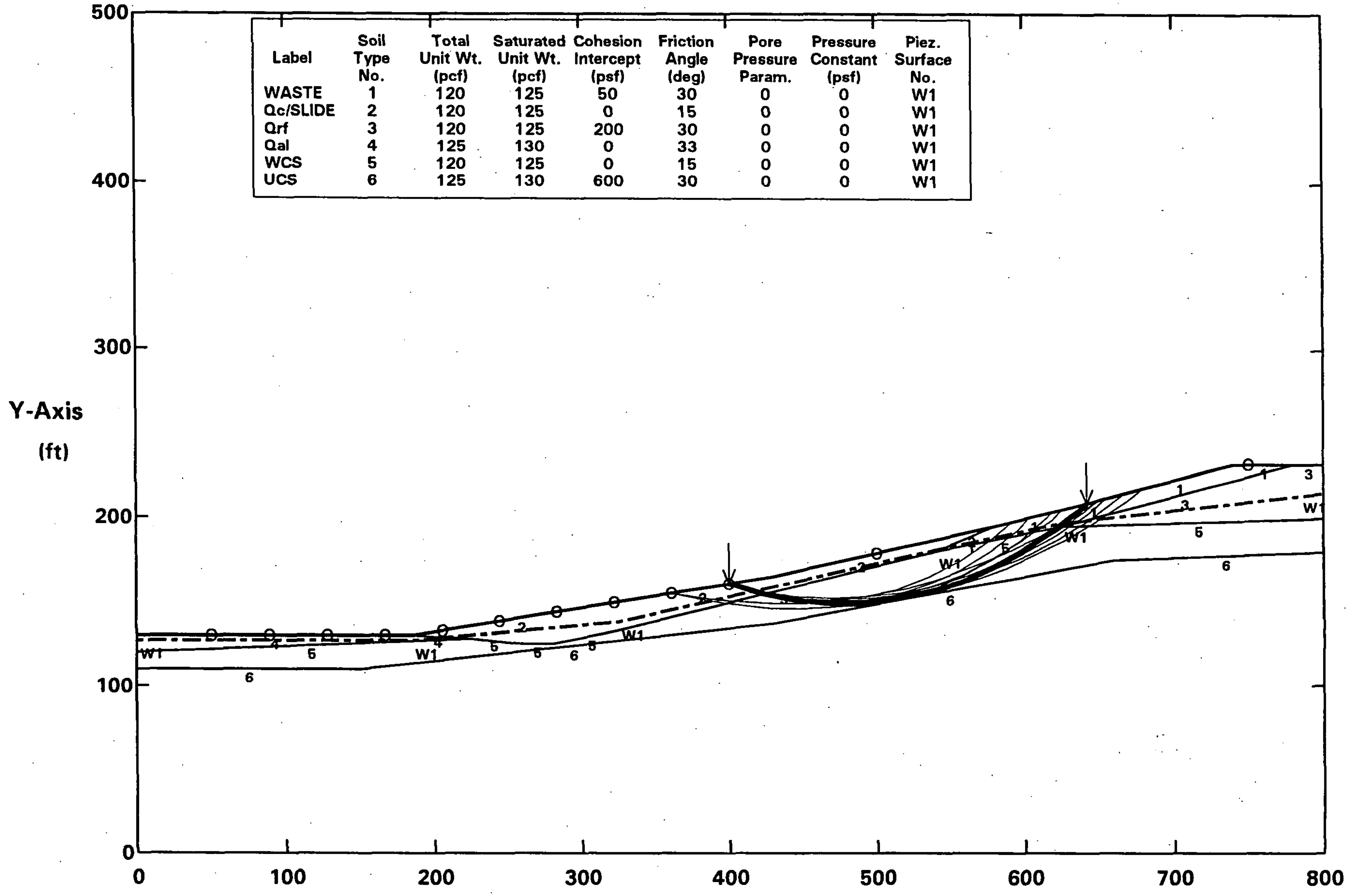
ROCKY FLATS OLF - M&E SECTION D - WCS = 15 deg - W/AVEGW - CIRCULAR - 0.06g
All surfaces evaluated. C:DEAC06.PLT By: STAN KLINE 10-26-04 12:20am



Factors Of Safety Calculated By The Modified Bishop Method

ROCKY FLATS OLF - M&E SECTION D - WCS = 15 deg - W/AVEGW - CIRCULAR - 0.06g
Ten Most Critical. C:DEAC06.PLT By: STAN KLINE 10-26-04 12:20am

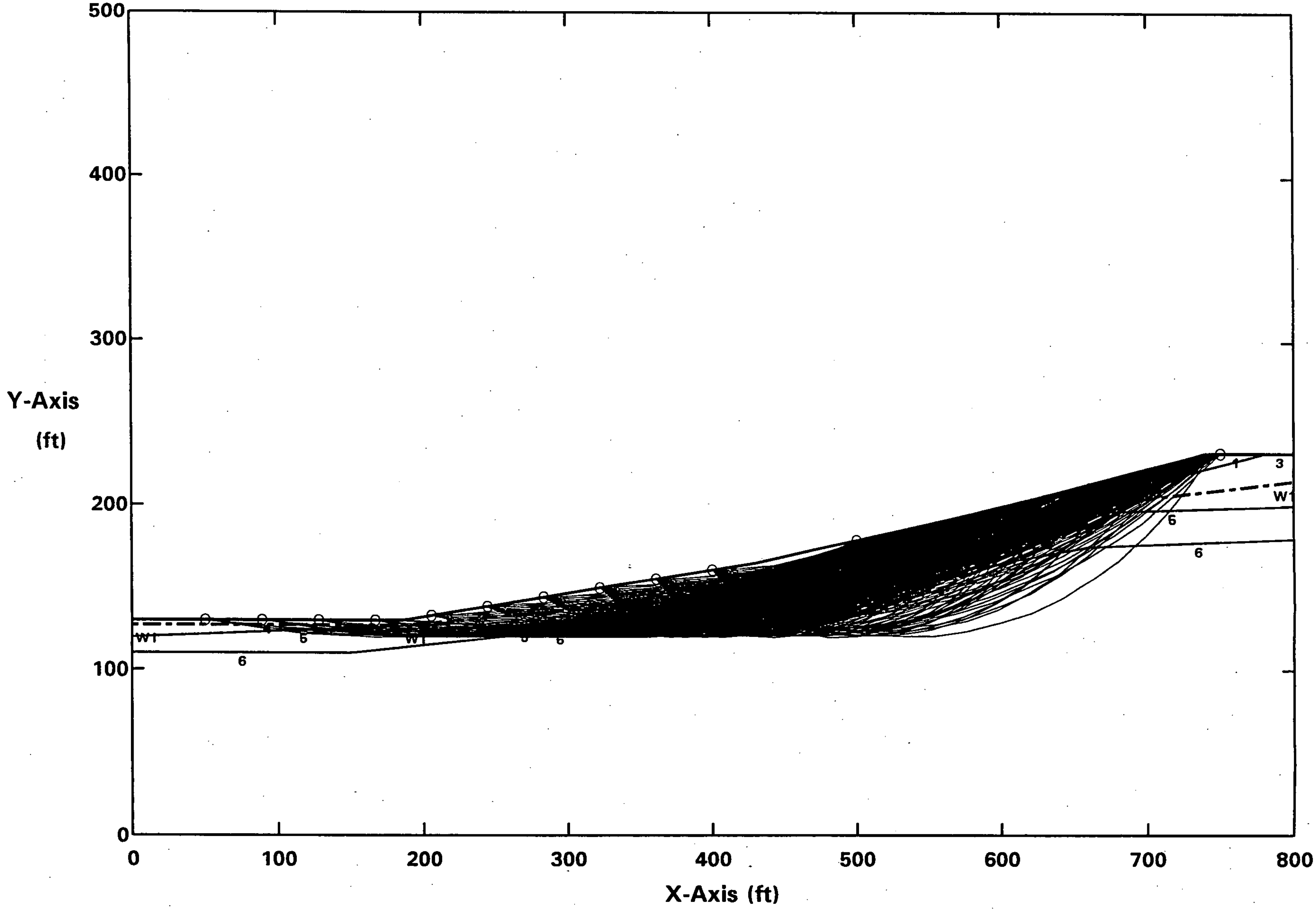
Label	Soil Type No.	Total Unit Wt. (pcf)	Saturated Unit Wt. (pcf)	Cohesion Intercept (psf)	Friction Angle (deg)	Pore Pressure Param.	Pressure Constant (psf)	Piez. Surface No.
WASTE	1	120	125	50	30	0	0	W1
Qc/SLIDE	2	120	125	0	15	0	0	W1
Qrf	3	120	125	200	30	0	0	W1
Qal	4	125	130	0	33	0	0	W1
WCS	5	120	125	0	15	0	0	W1
UCS	6	125	130	600	30	0	0	W1



PCSTABL5M/SI FSmin = 0.74 X-Axis (ft)
Factors Of Safety Calculated By The Modified Bishop Method

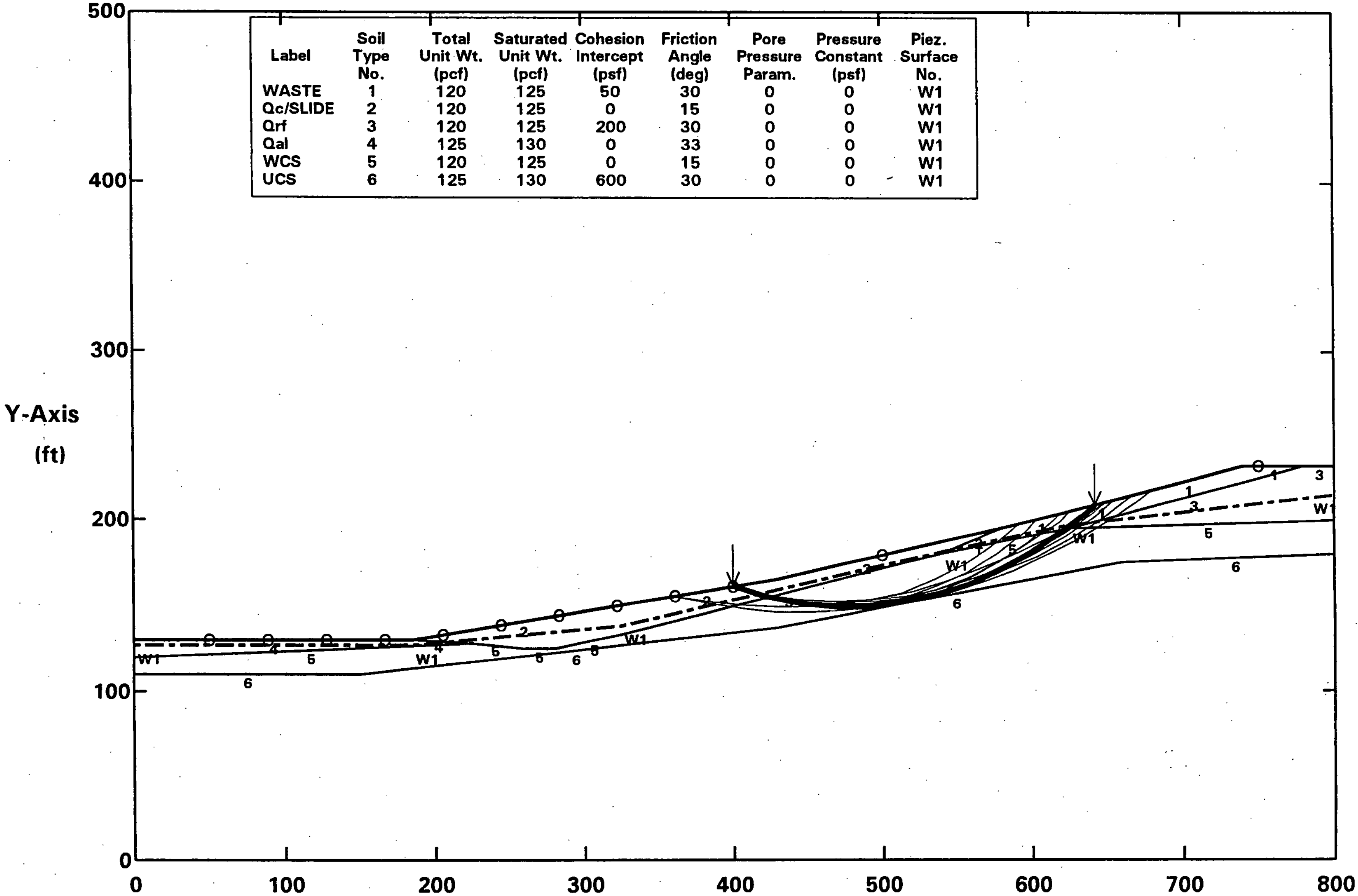
296

ROCKY FLATS OLF - M&E SECTION D - WCS=15deg - W/AVEGW - CIRCULAR - 0.00g(STATIC)
All surfaces evaluated. C:DEAC00.PLT By: STAN KLINE 10-26-04 12:19am



Factors Of Safety Calculated By The Modified Bishop Method

ROCKY FLATS OLF - M&E SECTION D - WCS=15deg - W/AVEGW - CIRCULAR - 0.00g(STATIC)
Ten Most Critical. C:DEAC00.PLT By: STAN KLINE 10-26-04 12:19am

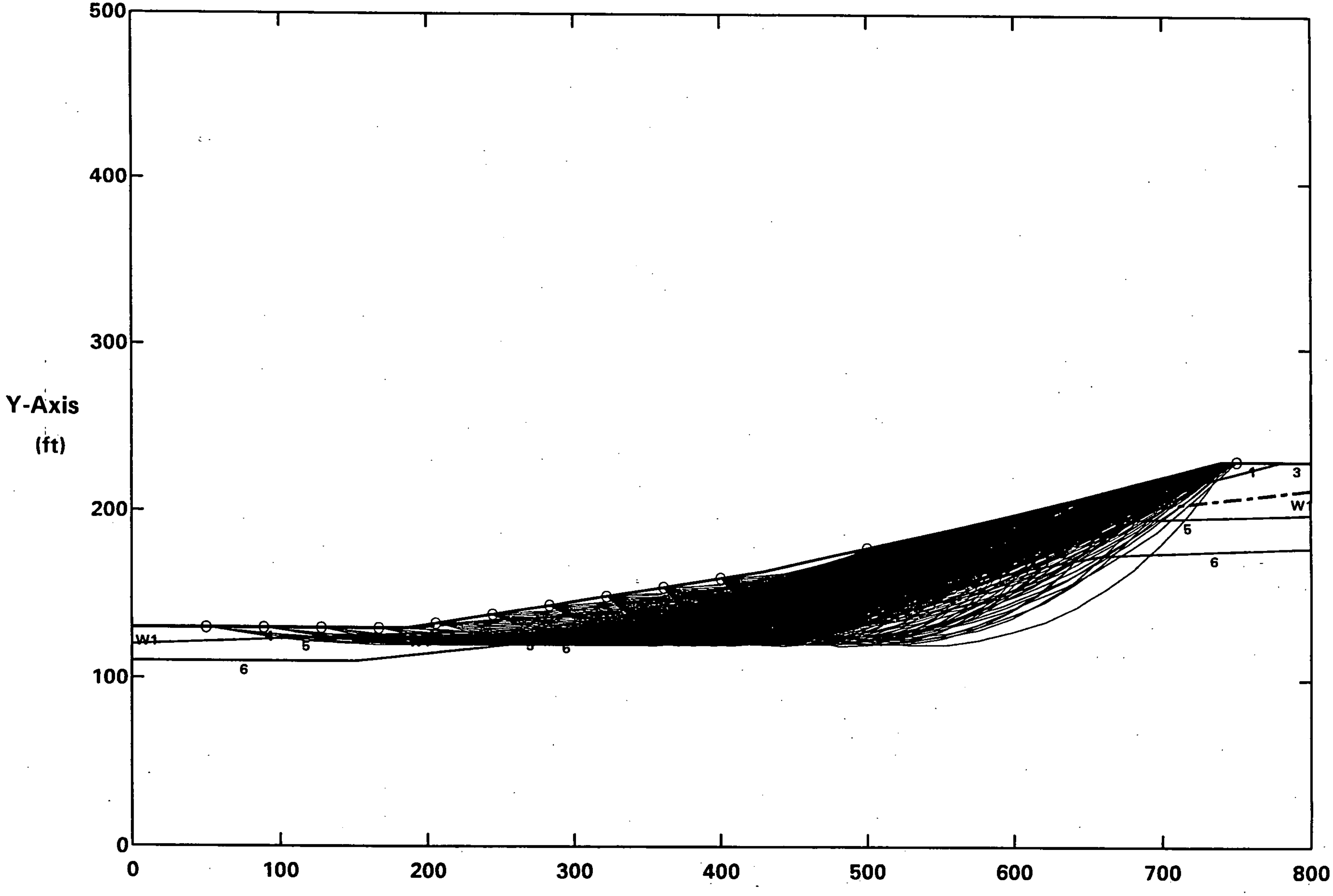


Label	Soil Type No.	Total Unit Wt. (pcf)	Saturated Unit Wt. (pcf)	Cohesion Intercept (psf)	Friction Angle (deg)	Pore Pressure Param.	Pressure Constant (psf)	Piez. Surface No.
WASTE	1	120	125	50	30	0	0	W1
Qc/SLIDE	2	120	125	0	15	0	0	W1
Qrf	3	120	125	200	30	0	0	W1
Qal	4	125	130	0	33	0	0	W1
WCS	5	120	125	0	15	0	0	W1
UCS	6	125	130	600	30	0	0	W1

PCSTABL5M/SI FSmin=0.97 X-Axis (ft)
Factors Of Safety Calculated By The Modified Bishop Method

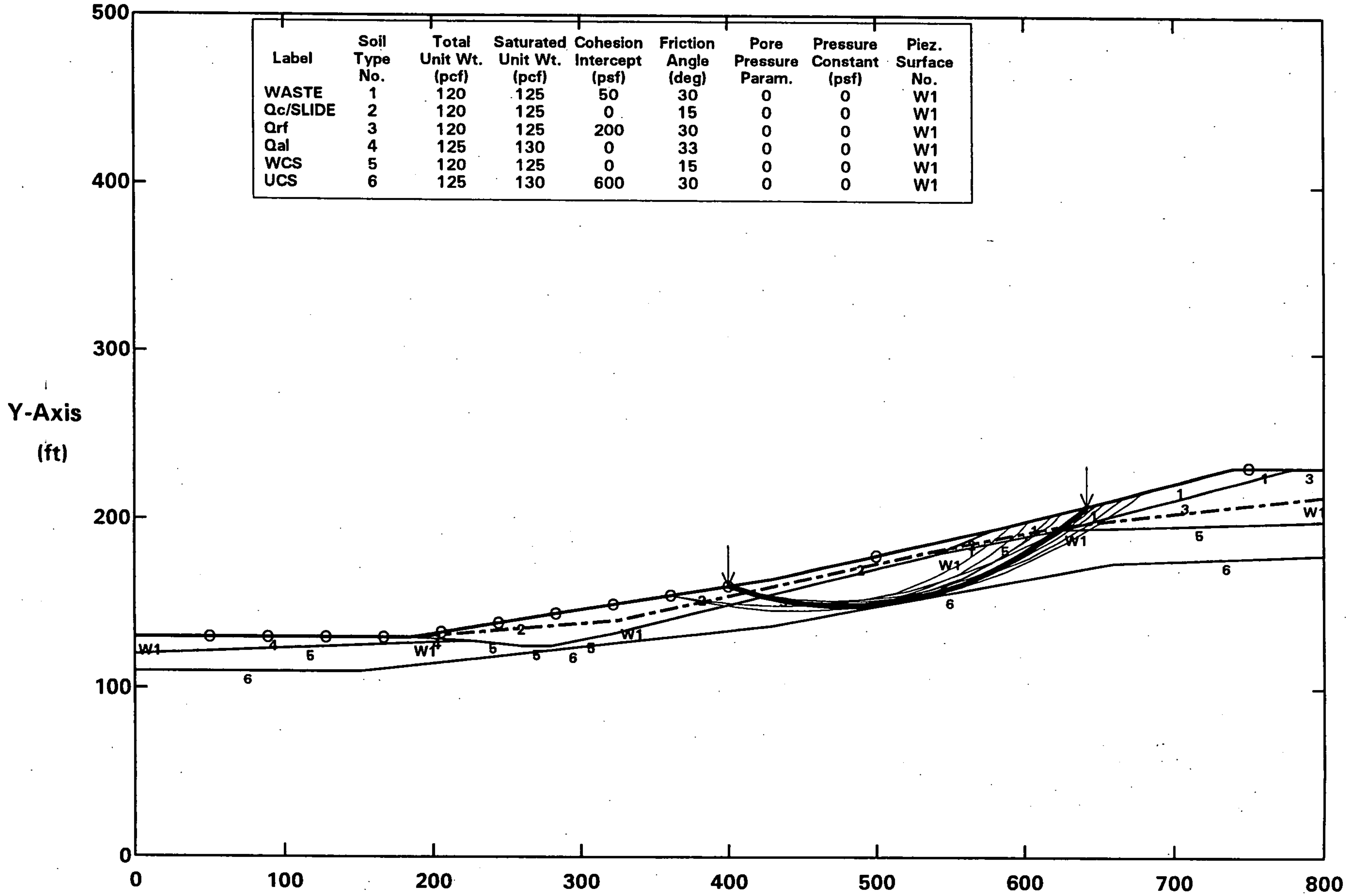
292

ROCKY FLATS OLF - M&E SECTION D - WCS = 15 deg - W/HIGHGW - CIRCULAR - 0.06g
All surfaces evaluated. C:DEHC06.PLT By: STAN KLINE 10-26-04 12:25am



Factors Of Safety Calculated By The Modified Bishop Method

ROCKY FLATS OLF - M&E SECTION D - WCS = 15 deg - W/HIGHGW - CIRCULAR - 0.06g
Ten Most Critical. C:DEHC06.PLT By: STAN KLINE 10-26-04 12:25am

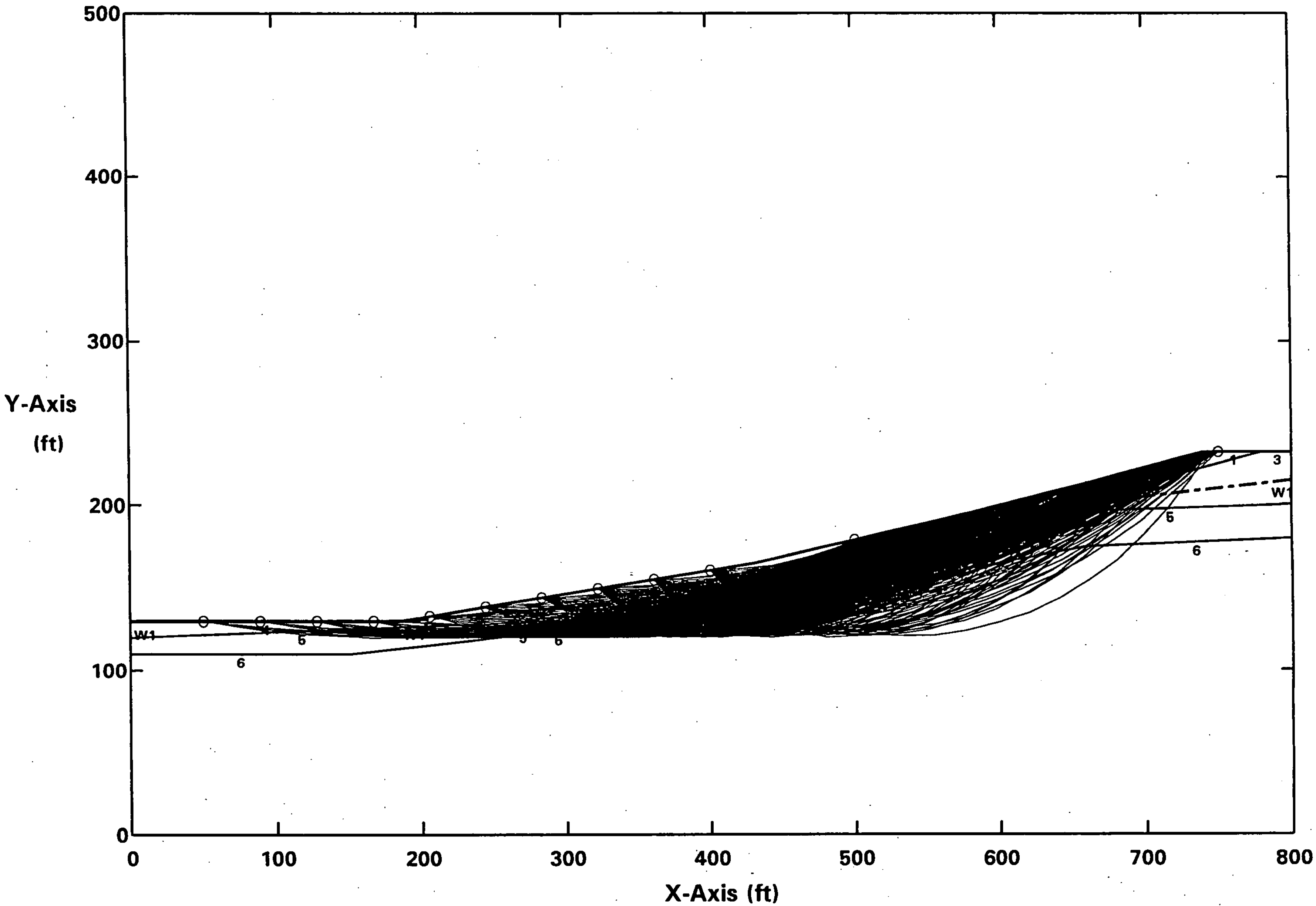


Label	Soil Type No.	Total Unit Wt. (pcf)	Saturated Unit Wt. (pcf)	Cohesion Intercept (psf)	Friction Angle (deg)	Pore Pressure Param.	Pressure Constant (psf)	Piez. Surface No.
WASTE	1	120	125	50	30	0	0	W1
Qc/SLIDE	2	120	125	0	15	0	0	W1
Qrf	3	120	125	200	30	0	0	W1
Qal	4	125	130	0	33	0	0	W1
WCS	5	120	125	0	15	0	0	W1
UCS	6	125	130	600	30	0	0	W1

PCSTABL5M/SI FSmin = 0.71 X-Axis (ft)
Factors Of Safety Calculated By The Modified Bishop Method

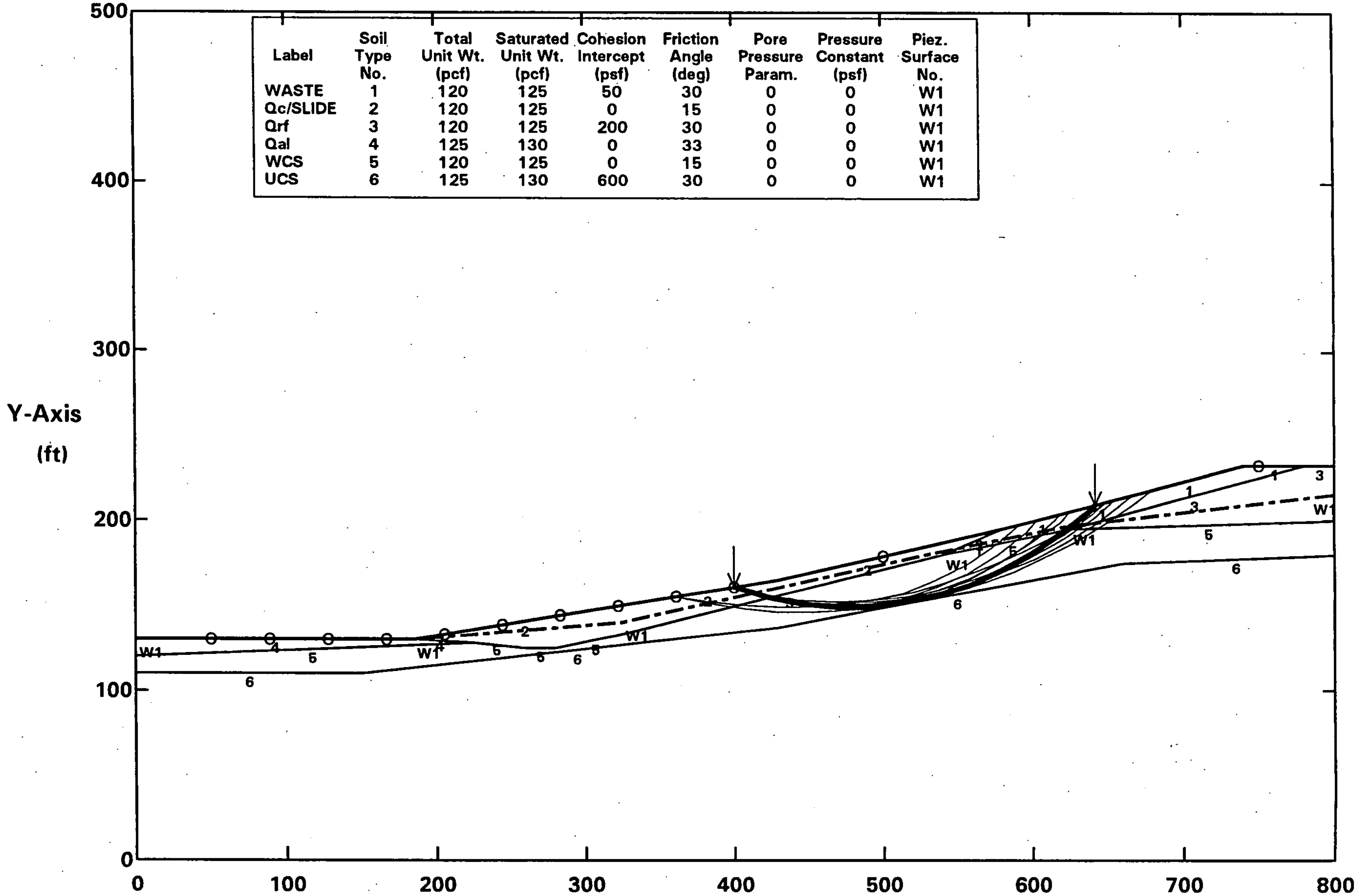
294

ROCKY FLATS OLF - M&E SECTION D - WCS = 15deg - W/HIGHGW - CIRCULAR - 0.0g(STATIC)
All surfaces evaluated. C:DEHC00.PLT By: STAN KLINE 10-26-04 12:24am



Factors Of Safety Calculated By The Modified Bishop Method

ROCKY FLATS OLF - M&E SECTION D - WCS=15deg - W/HIGHGW - CIRCULAR - 0.0g(STATIC)
Ten Most Critical. C:DEHC00.PLT By: STAN KLINE 10-26-04 12:24am

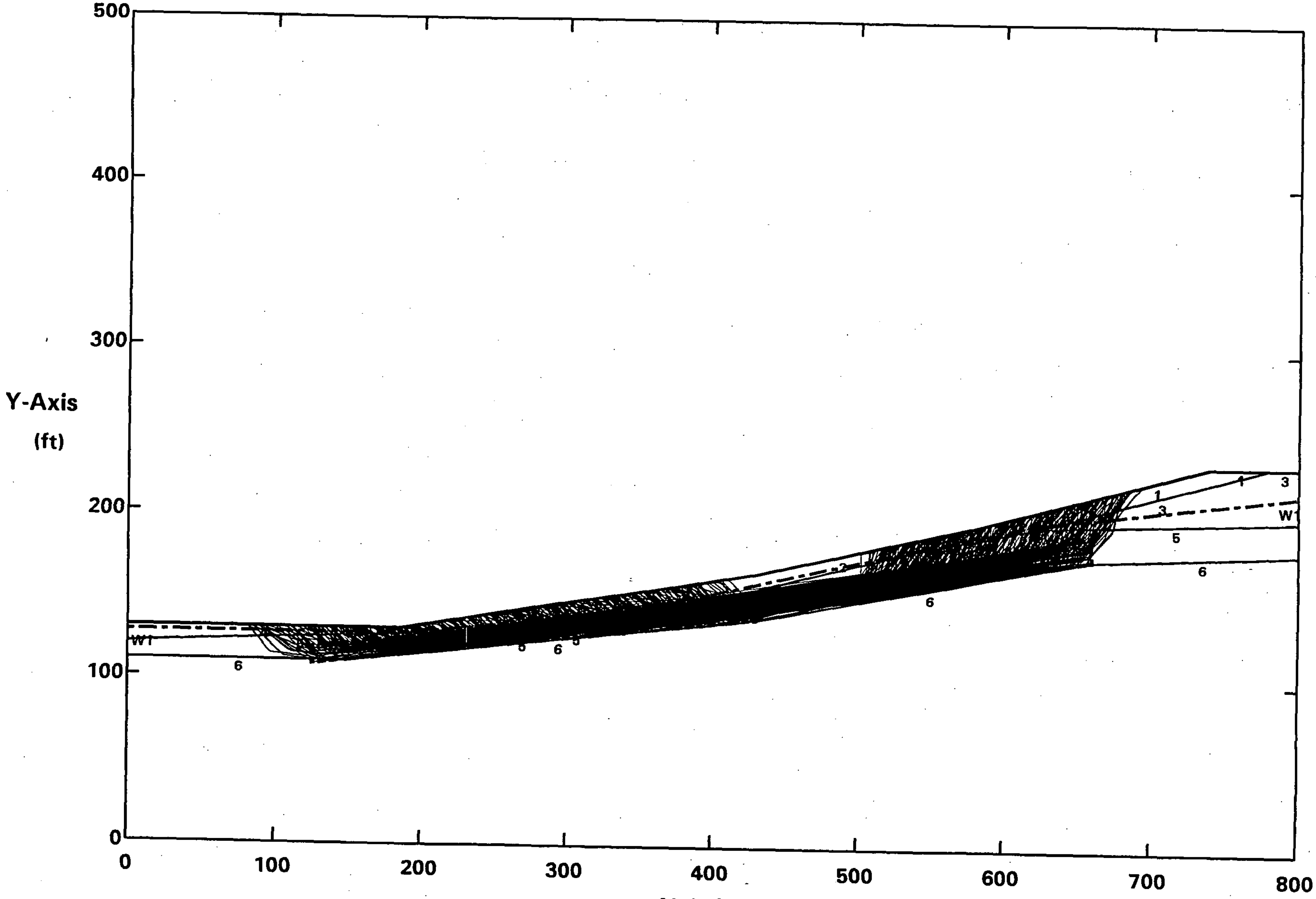


Label	Soil Type No.	Total Unit Wt. (pcf)	Saturated Unit Wt. (pcf)	Cohesion Intercept (psf)	Friction Angle (deg)	Pore Pressure Param.	Pressure Constant (psf)	Piez. Surface No.
WASTE	1	120	125	50	30	0	0	W1
Qc/SLIDE	2	120	125	0	15	0	0	W1
Qrf	3	120	125	200	30	0	0	W1
Qal	4	125	130	0	33	0	0	W1
WCS	5	120	125	0	15	0	0	W1
UCS	6	125	130	600	30	0	0	W1

PCSTABL5M/SI FSmin=0.94 X-Axis (ft)
Factors Of Safety Calculated By The Modified Bishop Method

29b

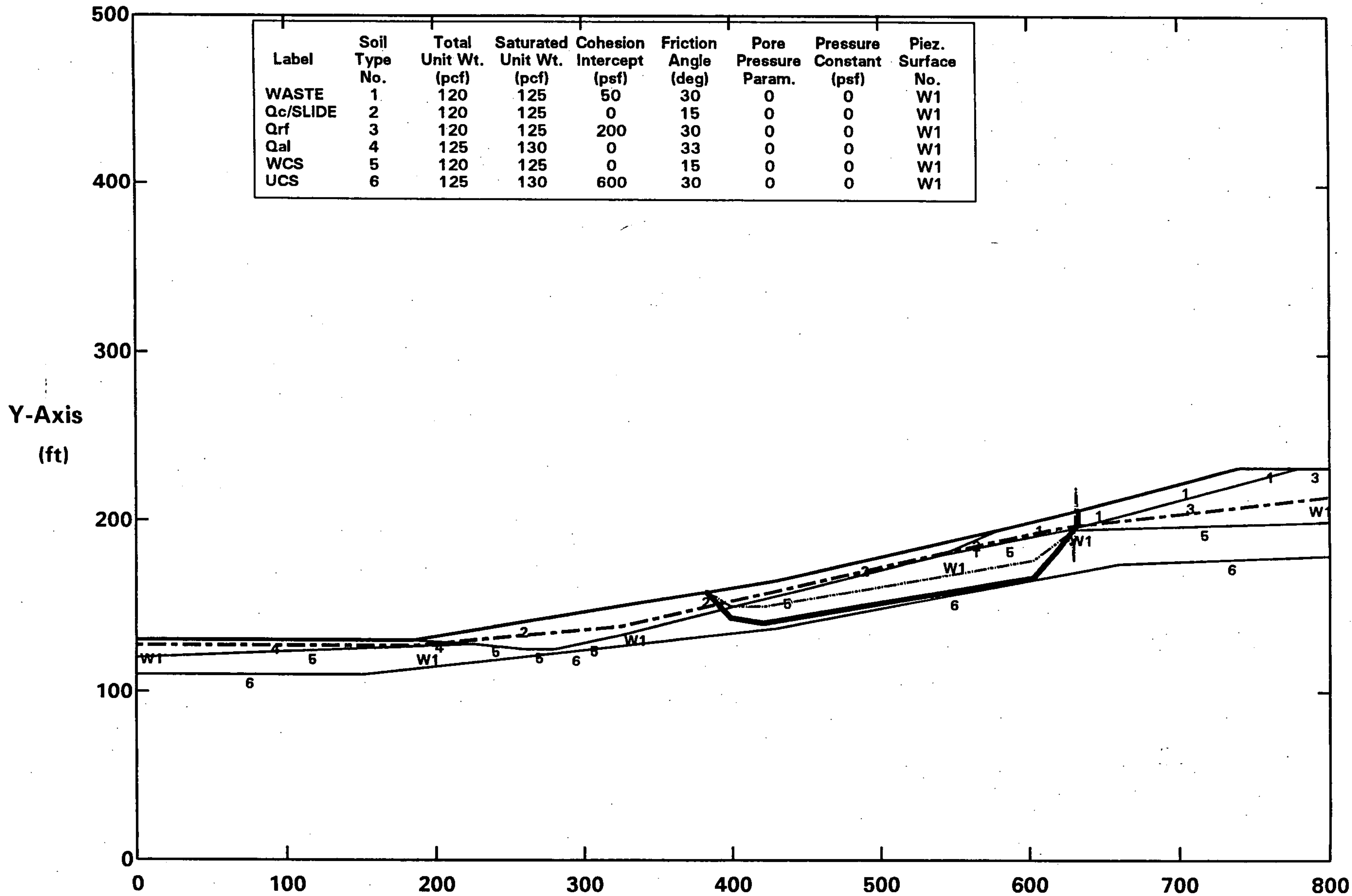
ROCKY FLATS OLF - M&E SECTION D - WCS = 15 deg - W/AVEGW - SLIDING BLOCK - 0.06g
All surfaces evaluated. C:DEAS06.PLT By: STAN KLINE 10-24-04 7:52pm



Factors Of Safety Calculated By The Modified Janbu Method

292

ROCKY FLATS OLF - M&E SECTION D - WCS=15 deg - W/AVEGW - SLIDING BLOCK - 0.06g
Surface #1-DEAS06.OUT. C:DEAS06SP.PLT By: STAN KLINE 10-24-04 7:53pm

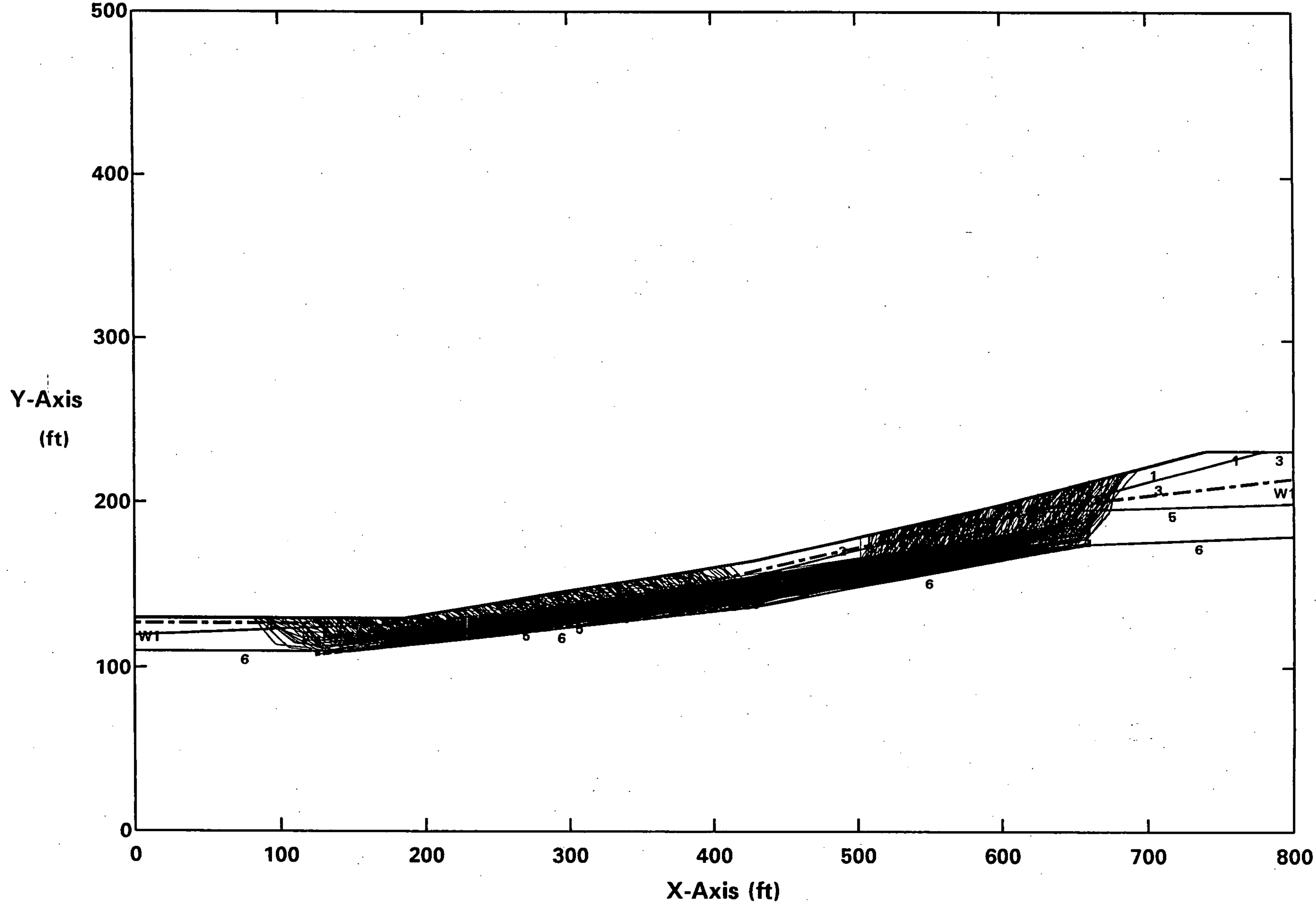


Label	Soil Type No.	Total Unit Wt. (pcf)	Saturated Unit Wt. (pcf)	Cohesion Intercept (psf)	Friction Angle (deg)	Pore Pressure Param.	Pressure Constant (psf)	Piez. Surface No.
WASTE	1	120	125	50	30	0	0	W1
Qc/SLIDE	2	120	125	0	15	0	0	W1
Qrf	3	120	125	200	30	0	0	W1
Qal	4	125	130	0	33	0	0	W1
WCS	5	120	125	0	15	0	0	W1
UCS	6	125	130	600	30	0	0	W1

PCSTABL5M/SI FS=0.80 Theta=8.42 X-Axis (ft)
Factors Of Safety Calculated By Spencer`s Method of Slices

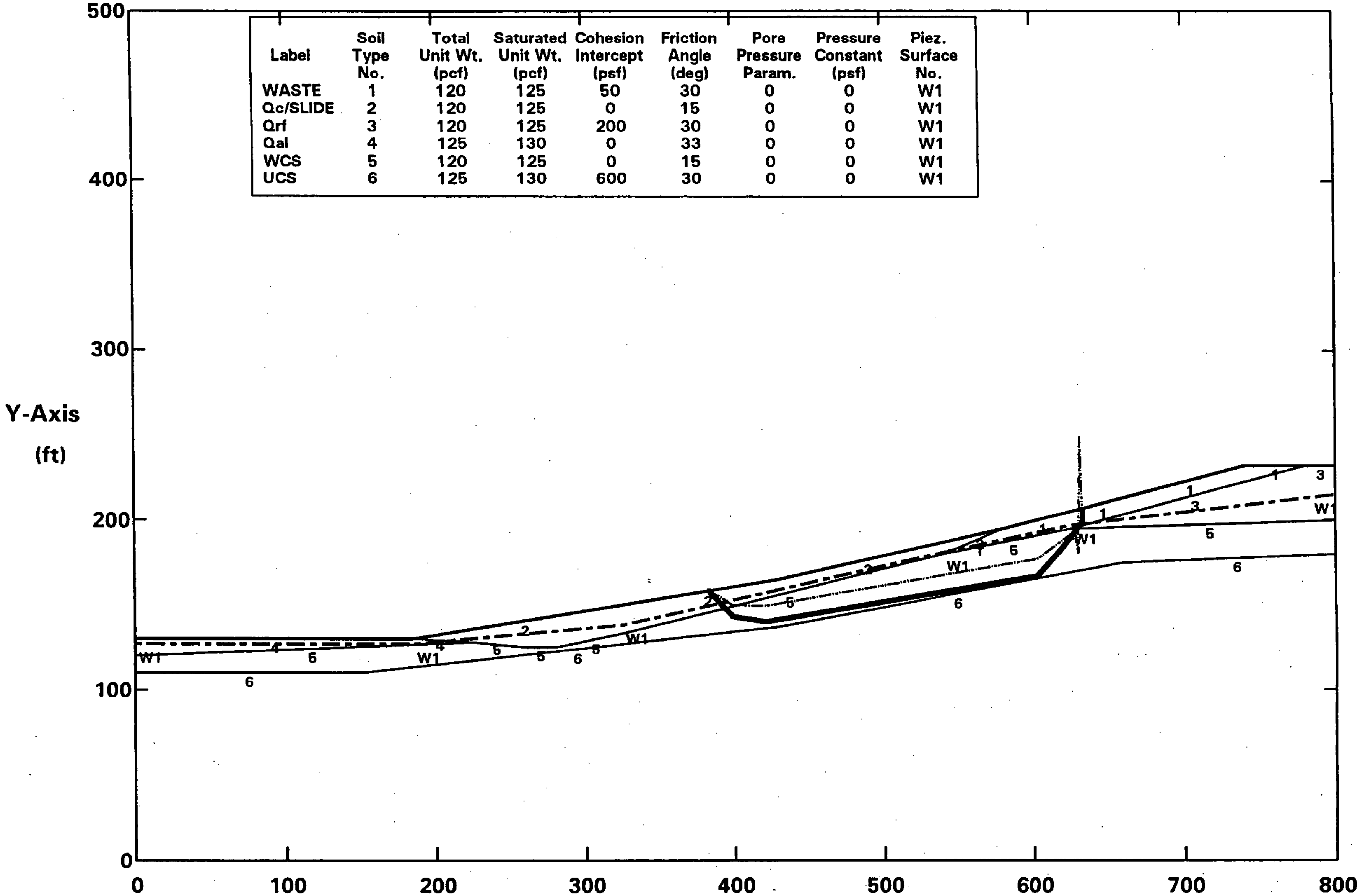
298

ROCKY FLATS OLF - M&E SECTION D - WCS = 15 deg - W/AVEGW - SLIDING BLOCK - 0.01g
All surfaces evaluated. C:DEAS01.PLT By: STAN KLINE 10-24-04 7:42pm



Factors Of Safety Calculated By The Modified Janbu Method

ROCKY FLATS OLF - M&E SECTION D - WCS=15 deg - W/AVEGW - SLIDING BLOCK - 0.01g
Surface #1-DEAS01.OUT. C:DEAS01SP.PLT By: STAN KLINE 10-24-04 7:44pm

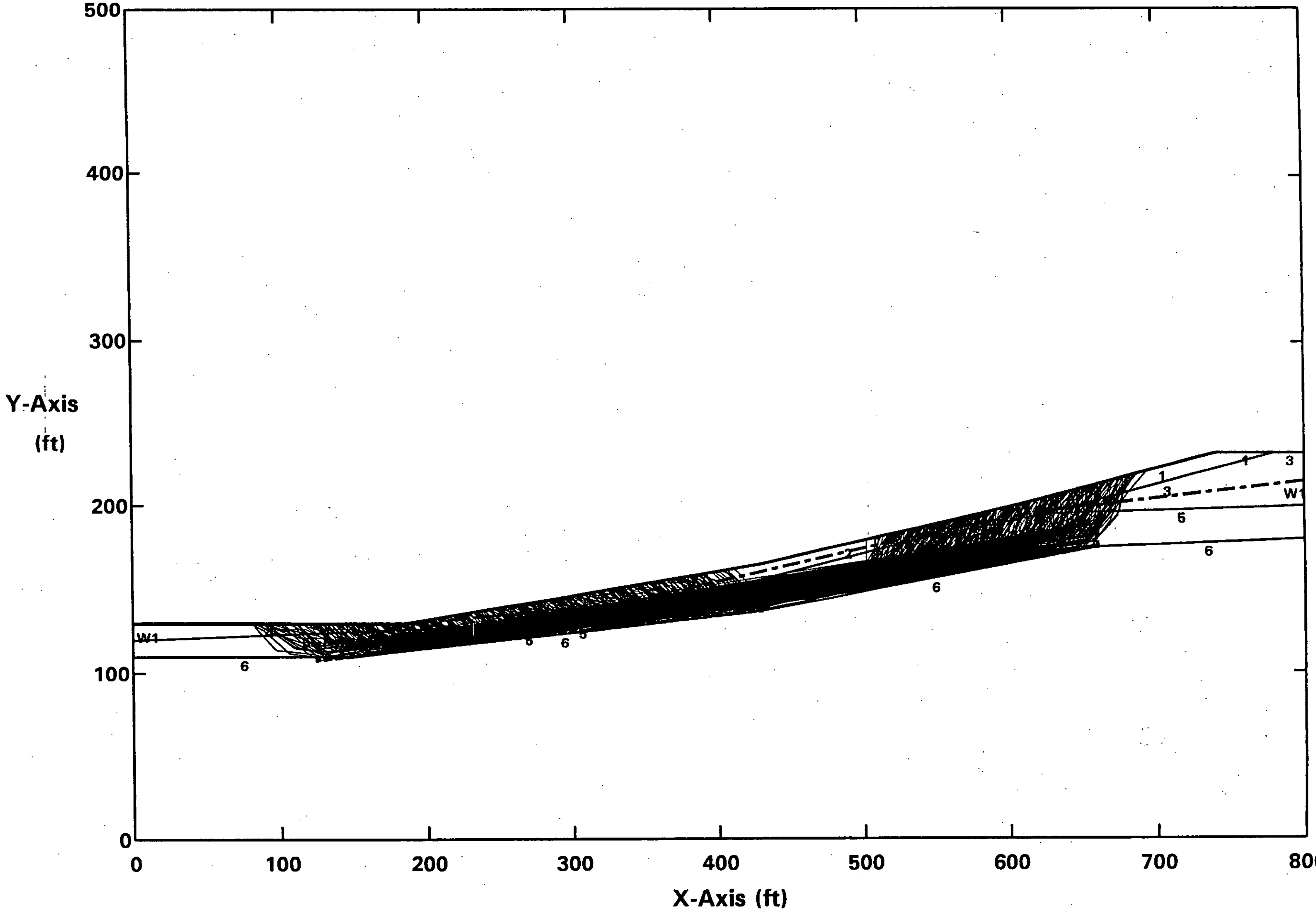


Label	Soil Type No.	Total Unit Wt. (pcf)	Saturated Unit Wt. (pcf)	Cohesion Intercept (psf)	Friction Angle (deg)	Pore Pressure Param.	Pressure Constant (psf)	Piez. Surface No.
WASTE	1	120	125	50	30	0	0	W1
Qc/SLIDE	2	120	125	0	15	0	0	W1
Qrf	3	120	125	200	30	0	0	W1
Qal	4	125	130	0	33	0	0	W1
WCS	5	120	125	0	15	0	0	W1
UCS	6	125	130	600	30	0	0	W1

PCSTABL5M/SI FS=1.02 Theta=8.76 X-Axis (ft)
Factors Of Safety Calculated By Spencer`s Method of Slices

300

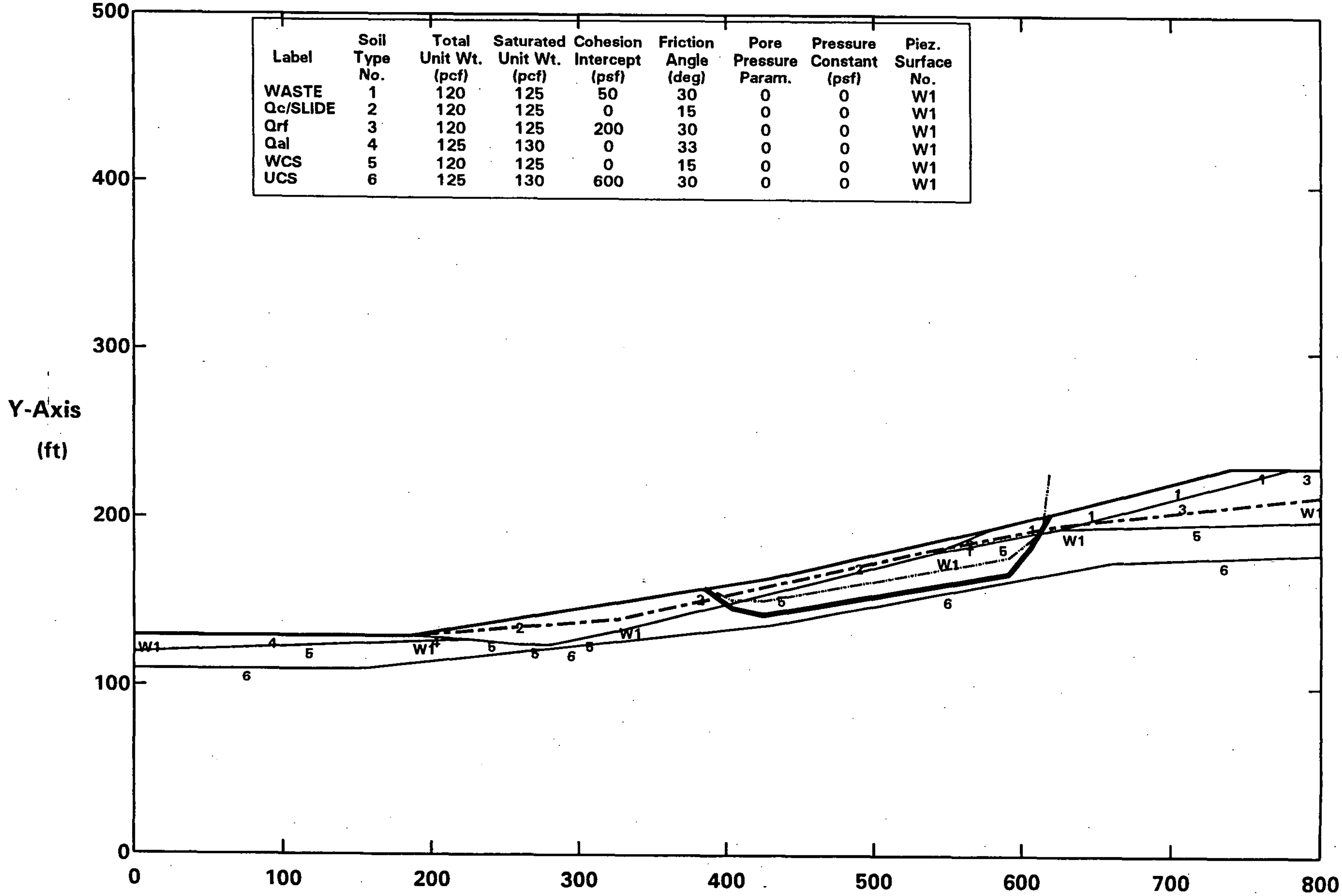
ROCKY FLATS OLF - M&E SECTION D - WCS = 15 deg - W/HIGHGW - SLIDING BLOCK - 0.06g
All surfaces evaluated. C:DEHS06.PLT By: STAN KLINE 10-24-04 8:27pm



Factors Of Safety Calculated By The Modified Janbu Method

39

ROCKY FLATS OLF - M&E SECTION D - WCS = 15 deg - W/HIGHGW - SLIDING BLOCK - 0.06g
Surface #1-DEHS06.OUT. C:DEHS06SP.PLT By: STAN KLINE 10-24-04 8:30pm

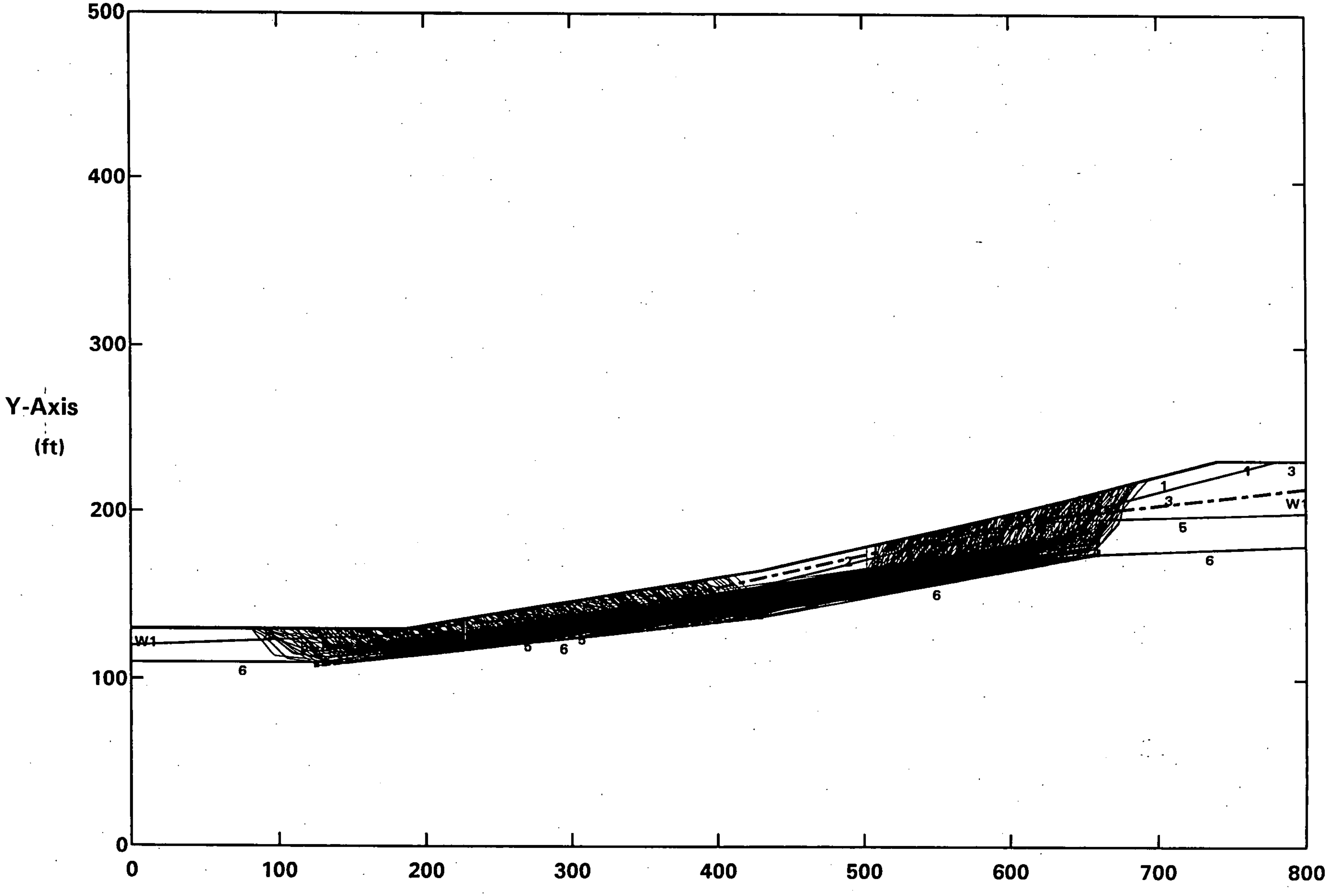


Label	Soil Type No.	Total Unit Wt. (pcf)	Saturated Unit Wt. (pcf)	Cohesion Intercept (psf)	Friction Angle (deg)	Pore Pressure Param.	Pressure Constant (psf)	Piez. Surface No.
WASTE	1	120	125	50	30	0	0	W1
Qc/SLIDE	2	120	125	0	15	0	0	W1
Qrf	3	120	125	200	30	0	0	W1
Qal	4	125	130	0	33	0	0	W1
WCS	5	120	125	0	15	0	0	W1
UCS	6	125	130	600	30	0	0	W1

PCSTABL5M/SI FS = 0.76 Theta = 8.79 X-Axis (ft)
Factors Of Safety Calculated By Spencer`s Method of Slices

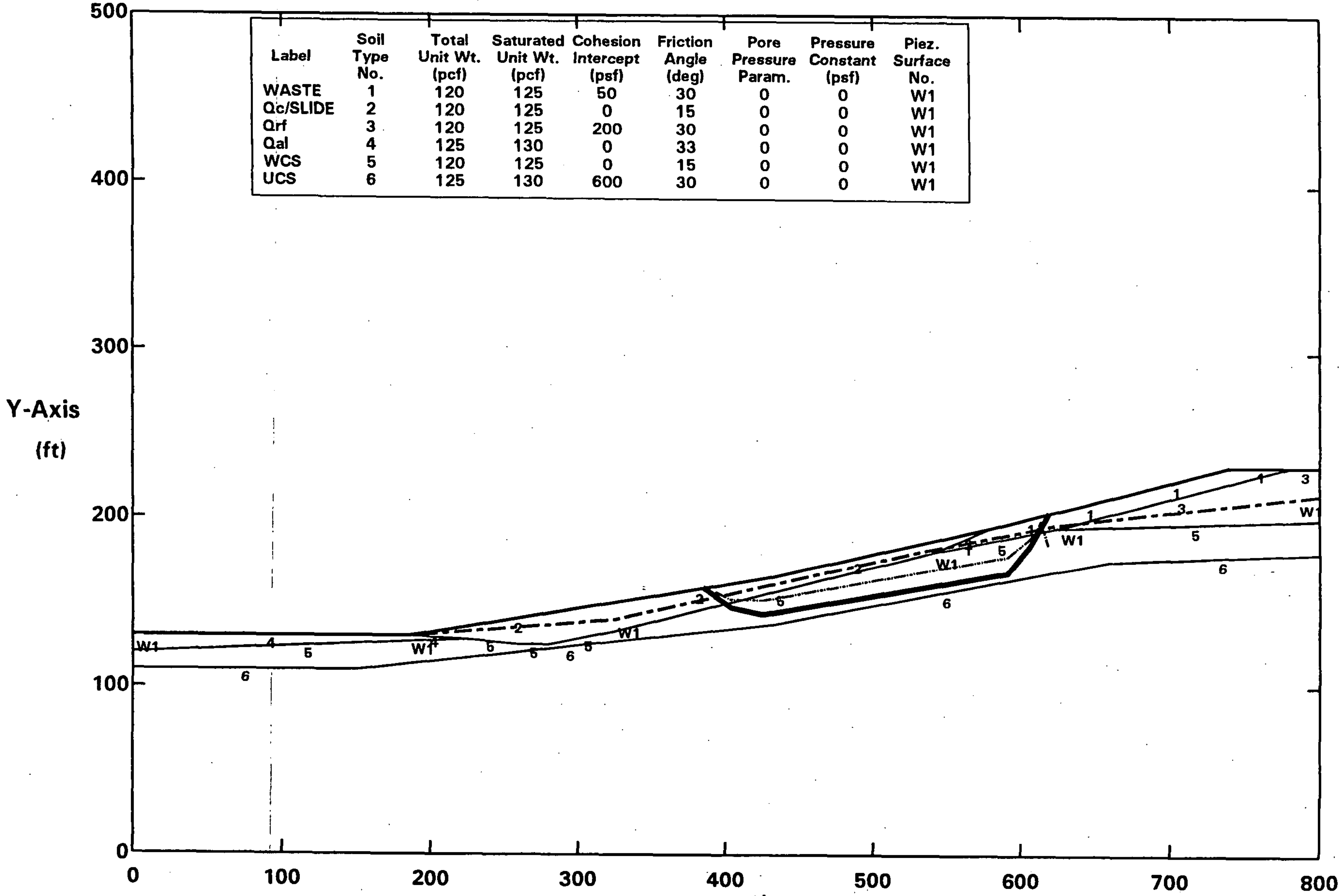
302

ROCKY FLATS OLF - M&E SECTION D - WCS=15 deg - W/HIGHGW - SLIDING BLOCK - 0.005g
All surfaces evaluated. C:DEHS01.PLT By: STAN KLINE 10-24-04 8:24pm



Factors Of Safety Calculated By The Modified Janbu Method

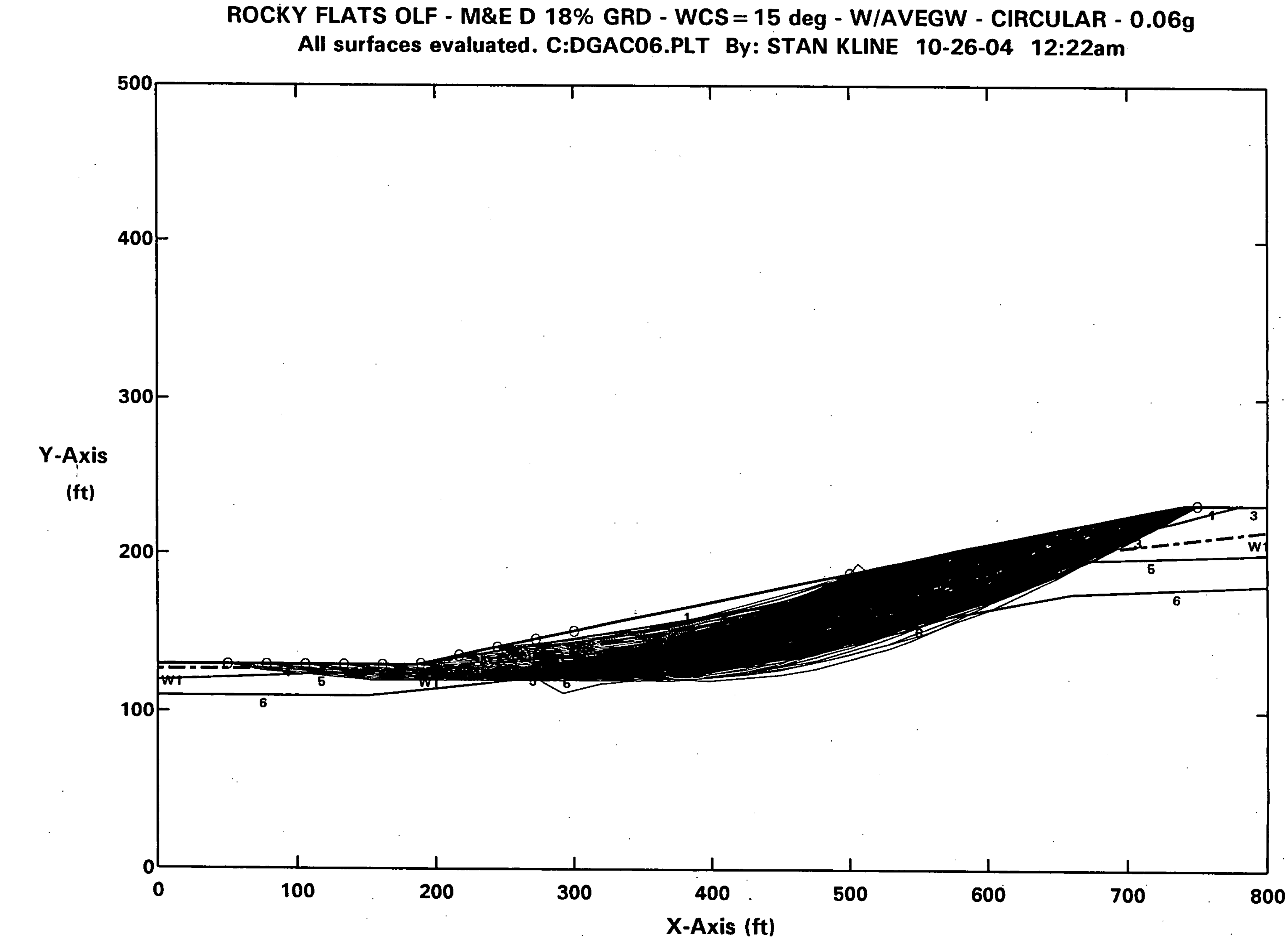
ROCKY FLATS OLF - M&E SECTION D - WCS=15 deg - W/HIGHGW - SLIDING BLOCK - 0.005g
Surface #1-DEHS01.OUT. C:DEHS01SP.PLT By: STAN KLINE 10-24-04 8:26pm



Label	Soil Type No.	Total Unit Wt. (pcf)	Saturated Unit Wt. (pcf)	Cohesion Intercept (psf)	Friction Angle (deg)	Pore Pressure Param.	Pressure Constant (psf)	Piez. Surface No.
WASTE	1	120	125	50	30	0	0	W1
Qc/SLIDE	2	120	125	0	15	0	0	W1
Qrf	3	120	125	200	30	0	0	W1
Qal	4	125	130	0	33	0	0	W1
WCS	5	120	125	0	15	0	0	W1
UCS	6	125	130	600	30	0	0	W1

PCSTABL5M/SI FS=1.00 Theta=9.18 X-Axis (ft)
Factors Of Safety Calculated By Spencer`s Method of Slices

365

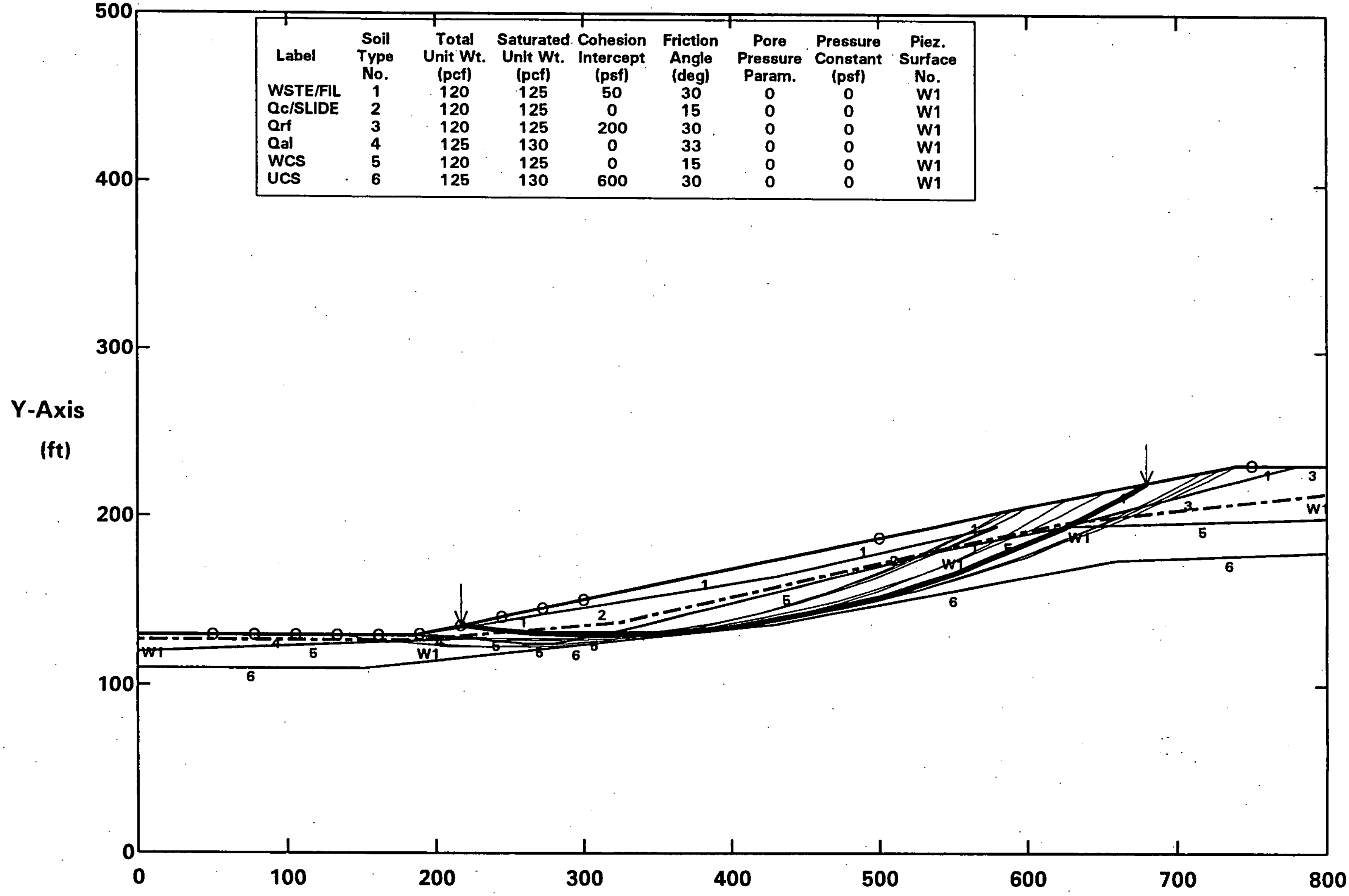


Factors Of Safety Calculated By The Modified Bishop Method

306

ROCKY FLATS OLF - M&E D 18% GRD - WCS=15 deg - W/AVEGW - CIRCULAR - 0.06g
Ten Most Critical. C:DGAC06.PLT By: STAN KLINE 10-26-04 12:22am

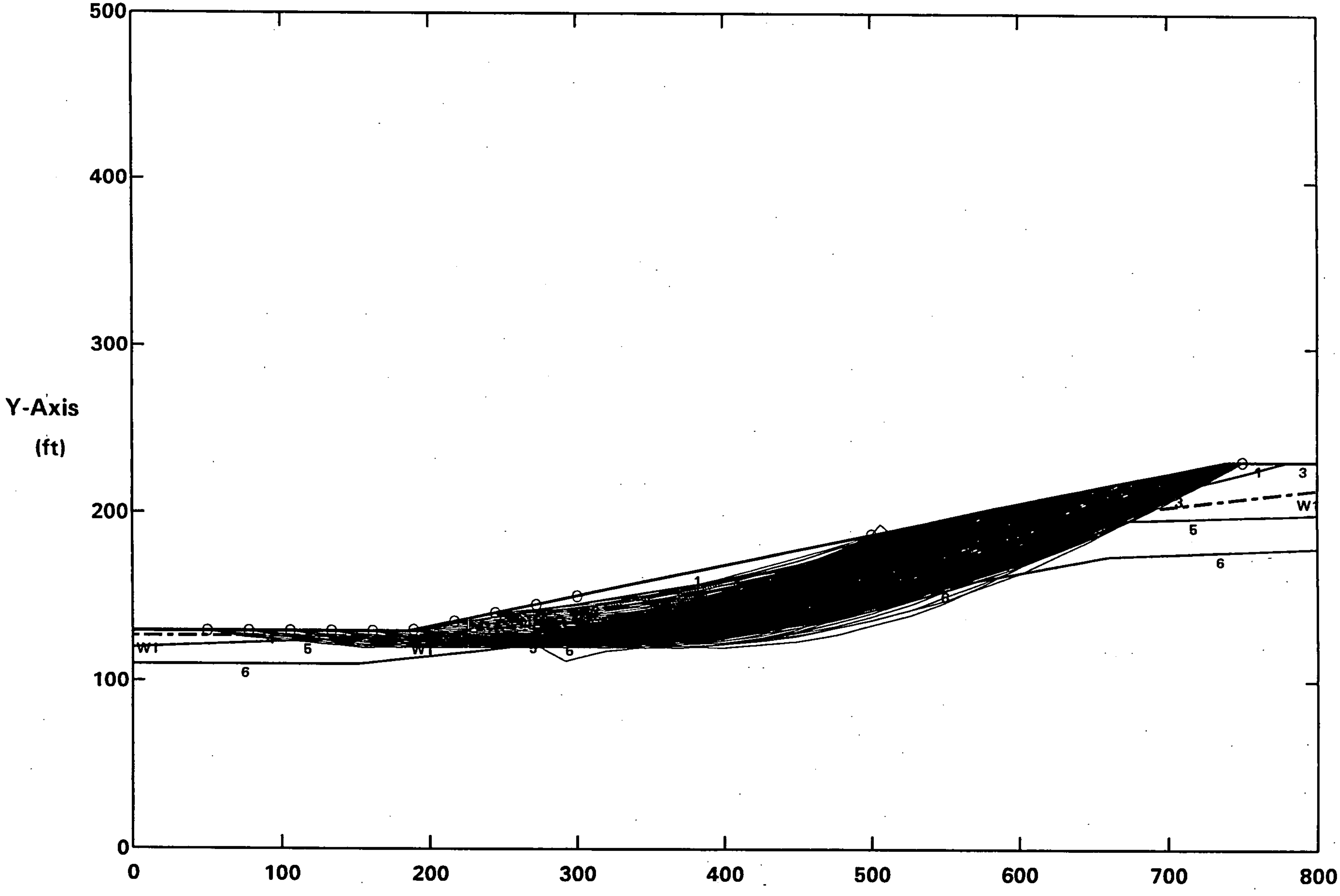
Label	Soil Type No.	Total Unit Wt. (pcf)	Saturated Unit Wt. (pcf)	Cohesion Intercept (psf)	Friction Angle (deg)	Pore Pressure Param.	Pressure Constant (psf)	Piez. Surface No.
WSTE/FIL	1	120	125	50	30	0	0	W1
Qc/SLIDE	2	120	125	0	15	0	0	W1
Qrf	3	120	125	200	30	0	0	W1
Qal	4	125	130	0	33	0	0	W1
WCS	5	120	125	0	15	0	0	W1
UCS	6	125	130	600	30	0	0	W1



PCSTABL5M/SI FSmin=0.92 X-Axis (ft)
Factors Of Safety Calculated By The Modified Bishop Method

307

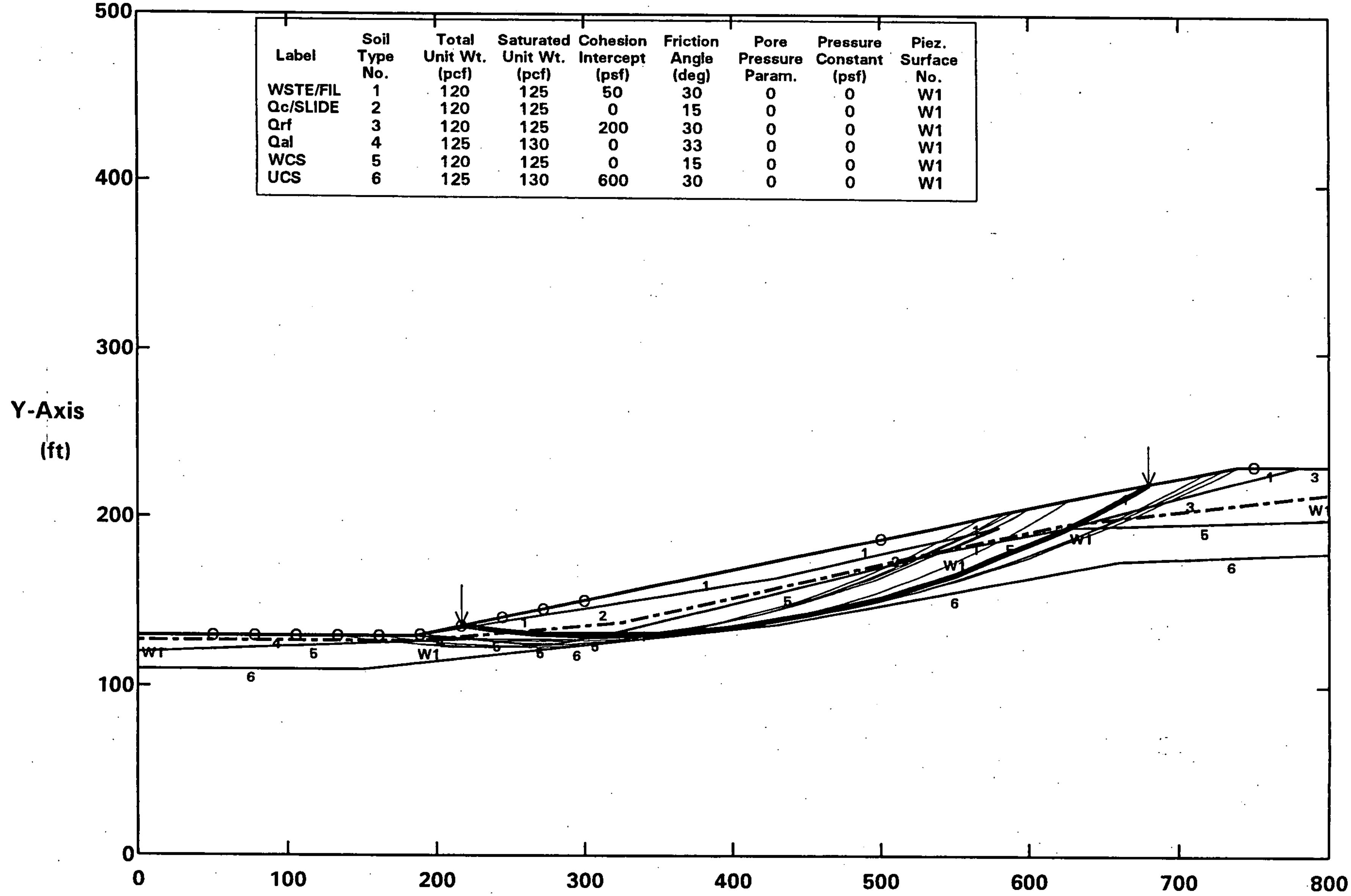
ROCKY FLATS OLF - M&E D 18% GRD - WCS = 15 deg - W/AVEGW - CIRCULAR - 0.04g
All surfaces evaluated. C:DGAC04.PLT By: STAN KLINE 10-26-04 12:21am



Factors Of Safety Calculated By The Modified Bishop Method

308

ROCKY FLATS OLF - M&E D 18% GRD - WCS=15 deg - W/AVEGW - CIRCULAR - 0.04g
Ten Most Critical. C:DGAC04.PLT By: STAN KLINE 10-26-04 12:21am

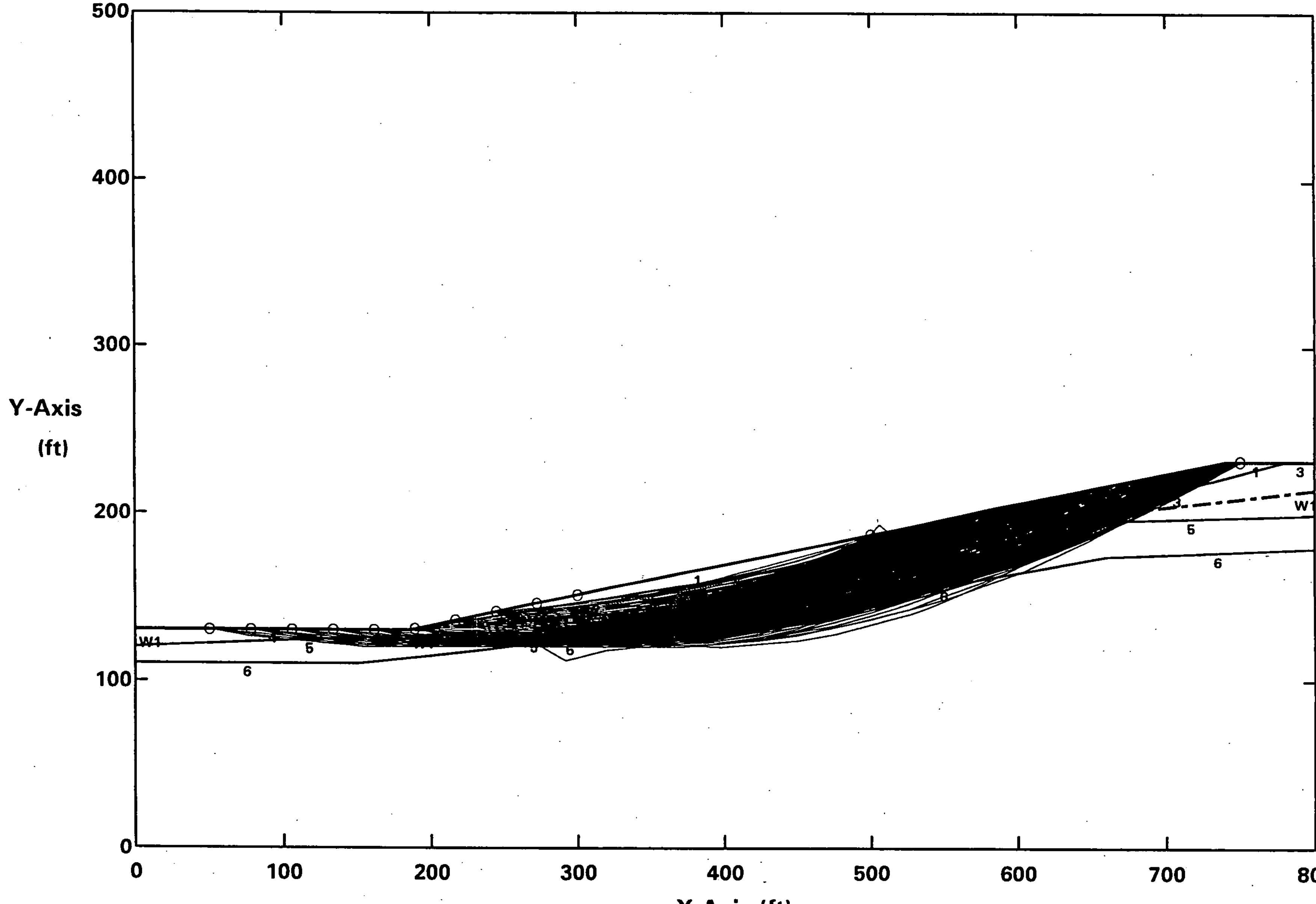


Label	Soil Type No.	Total Unit Wt. (pcf)	Saturated Unit Wt. (pcf)	Cohesion Intercept (psf)	Friction Angle (deg)	Pore Pressure Param.	Pressure Constant (psf)	Piez. Surface No.
WSTE/FIL	1	120	125	50	30	0	0	W1
Qc/SLIDE	2	120	125	0	15	0	0	W1
Qrf	3	120	125	200	30	0	0	W1
Qal	4	125	130	0	33	0	0	W1
WCS	5	120	125	0	15	0	0	W1
UCS	6	125	130	600	30	0	0	W1

PCSTABL5M/SI FSmin=1.01 X-Axis (ft)
Factors Of Safety Calculated By The Modified Bishop Method

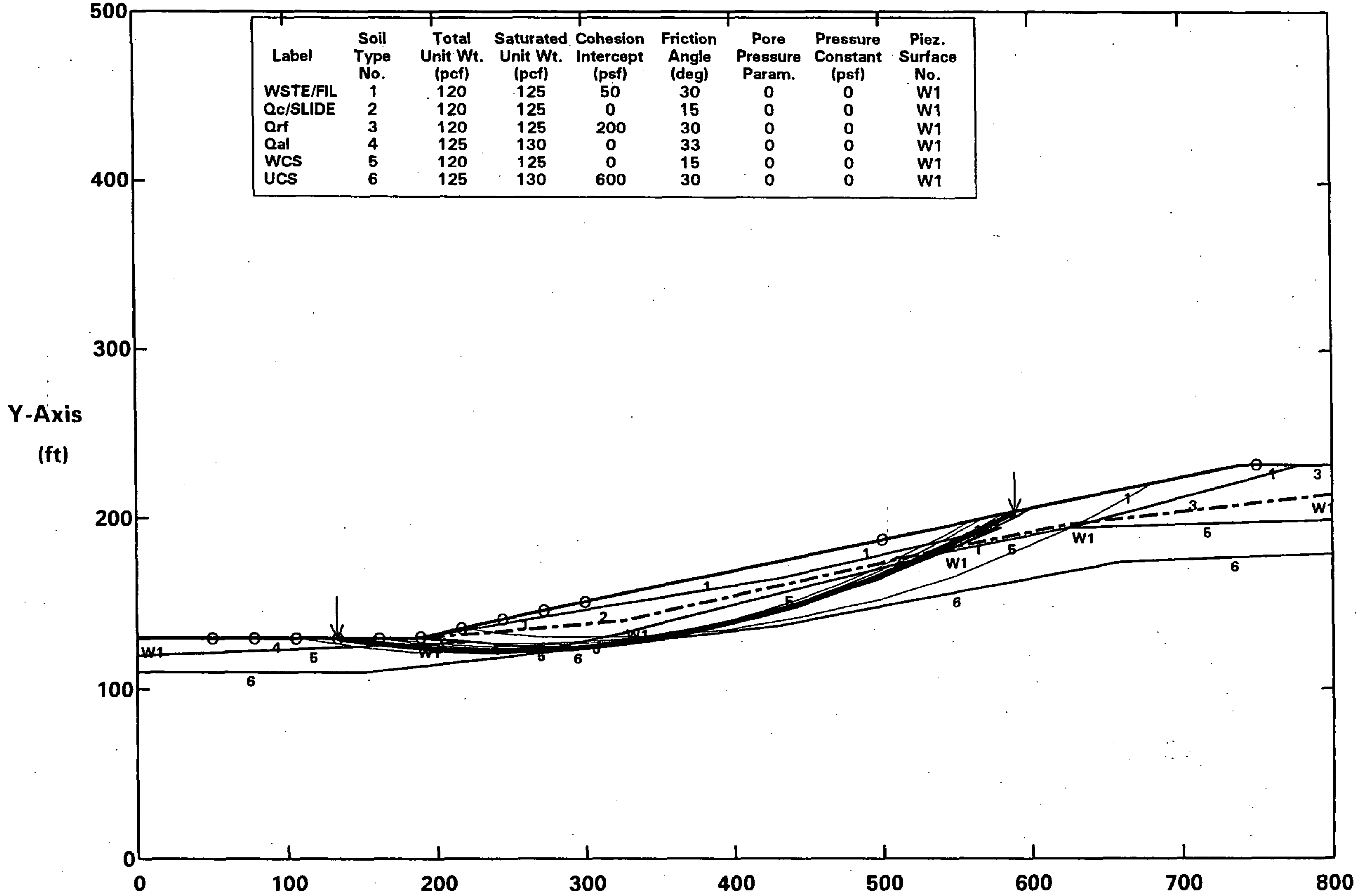
309

ROCKY FLATS OLF - M&E D 18% GRD - WCS = 15 deg - W/HIGHGW - CIRCULAR - 0.06g
All surfaces evaluated. C:DGHC06.PLT By: STAN KLINE 10-26-04 12:26am



Factors Of Safety Calculated By The Modified Bishop Method

ROCKY FLATS OLF - M&E D 18% GRD - WCS=15 deg - W/HIGHGW - CIRCULAR - 0.06g
Ten Most Critical. C:DGHC06.PLT By: STAN KLINE 10-26-04 12:26am

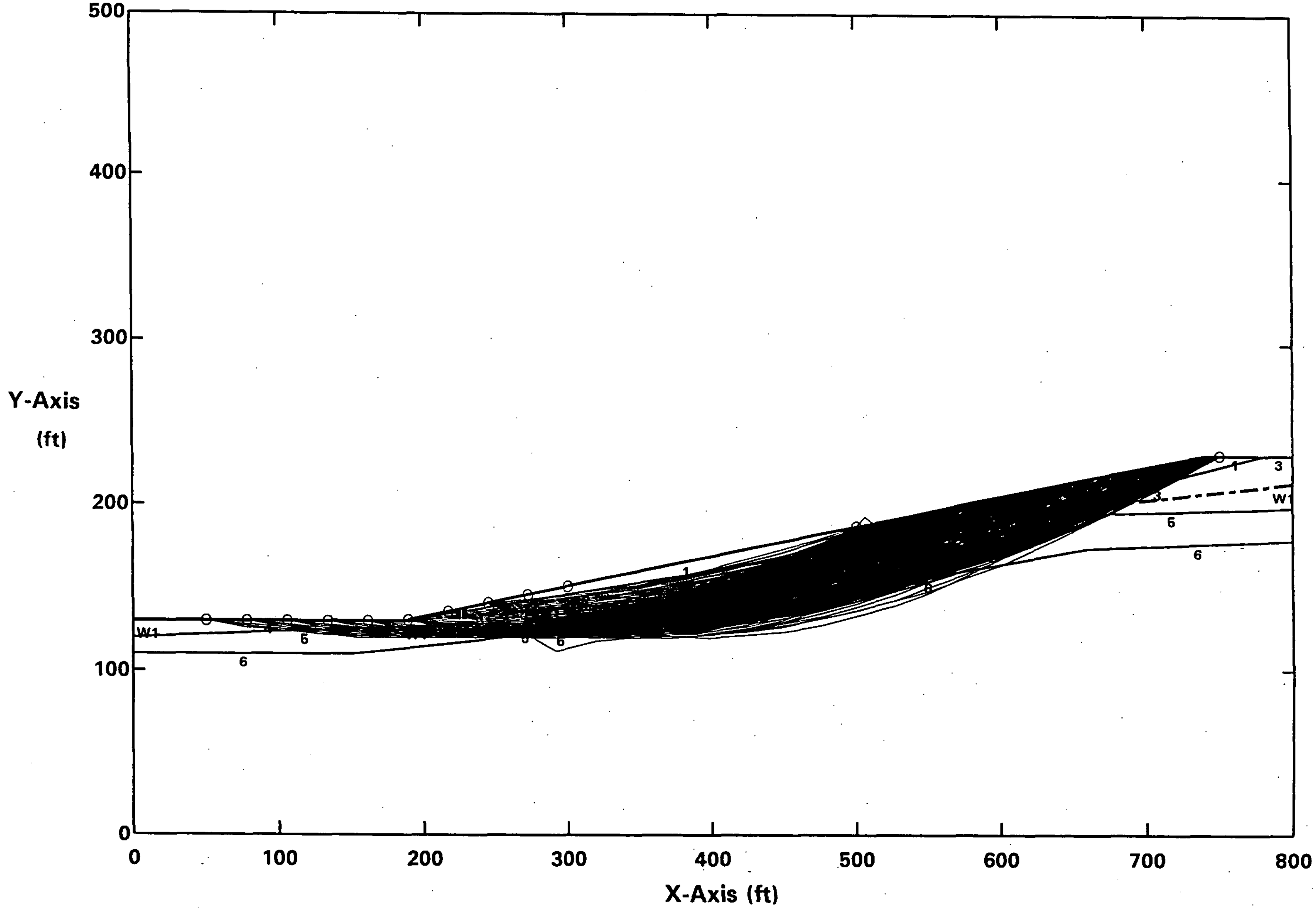


Label	Soil Type No.	Total Unit Wt. (pcf)	Saturated Unit Wt. (pcf)	Cohesion Intercept (psf)	Friction Angle (deg)	Pore Pressure Param.	Pressure Constant (psf)	Piez. Surface No.
WSTE/FIL	1	120	125	50	30	0	0	W1
Qc/SLIDE	2	120	125	0	15	0	0	W1
Qrf	3	120	125	200	30	0	0	W1
Qal	4	125	130	0	33	0	0	W1
WCS	5	120	125	0	15	0	0	W1
UCS	6	125	130	600	30	0	0	W1

PCSTABL5M/SI FSmin=0.88 X-Axis (ft)
Factors Of Safety Calculated By The Modified Bishop Method

3\1

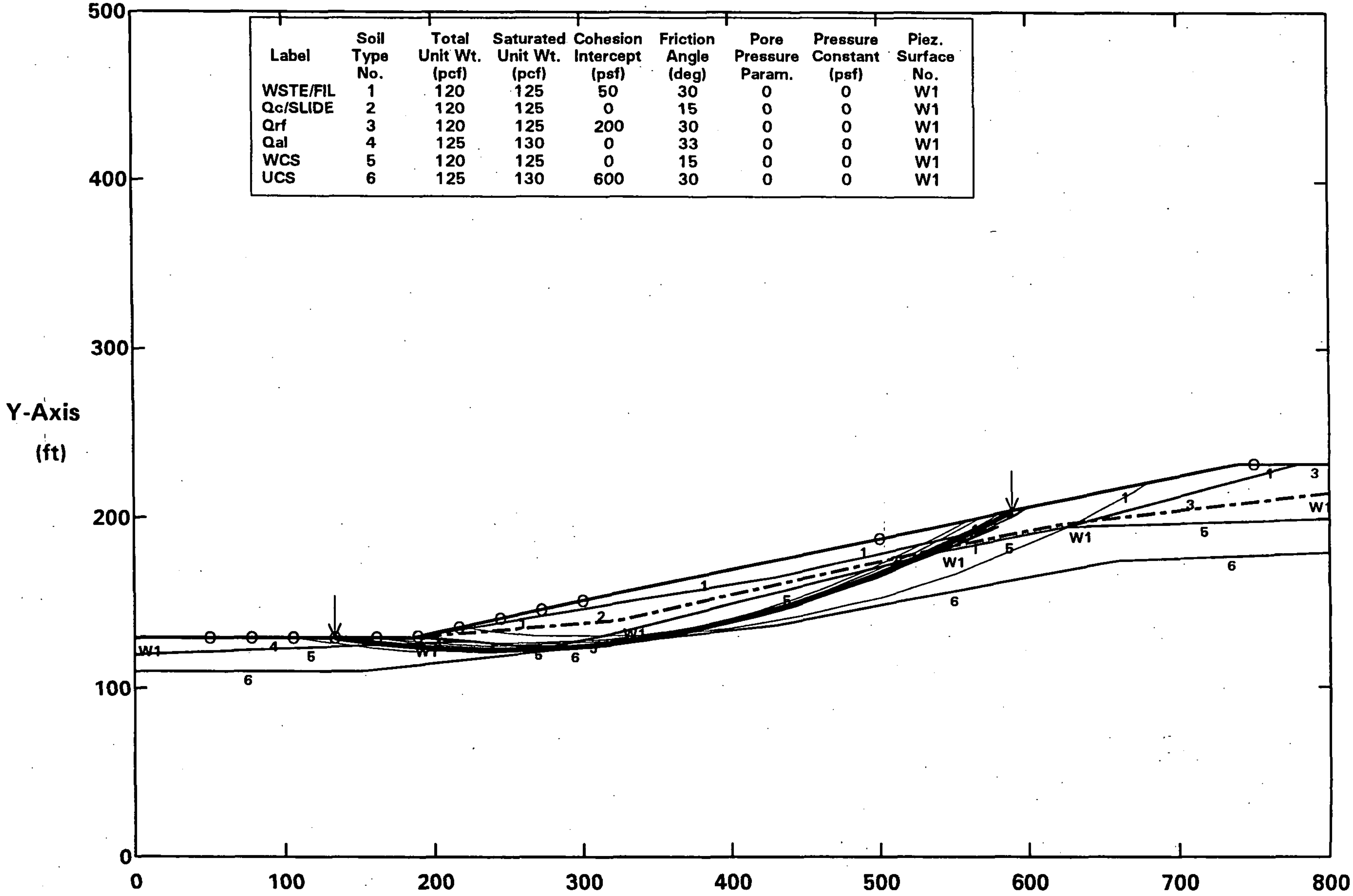
ROCKY FLATS OLF - M&E D 18% GRD - WCS = 15 deg - W/HIGHGW - CIRCULAR - 0.03g
All surfaces evaluated. C:DGHC03.PLT By: STAN KLINE 10-26-04 12:26am



Factors Of Safety Calculated By The Modified Bishop Method

312

ROCKY FLATS OLF - M&E D 18% GRD - WCS = 15 deg - W/HIGHGW - CIRCULAR - 0.03g
Ten Most Critical. C:DGHC03.PLT By: STAN KLINE 10-26-04 12:26am

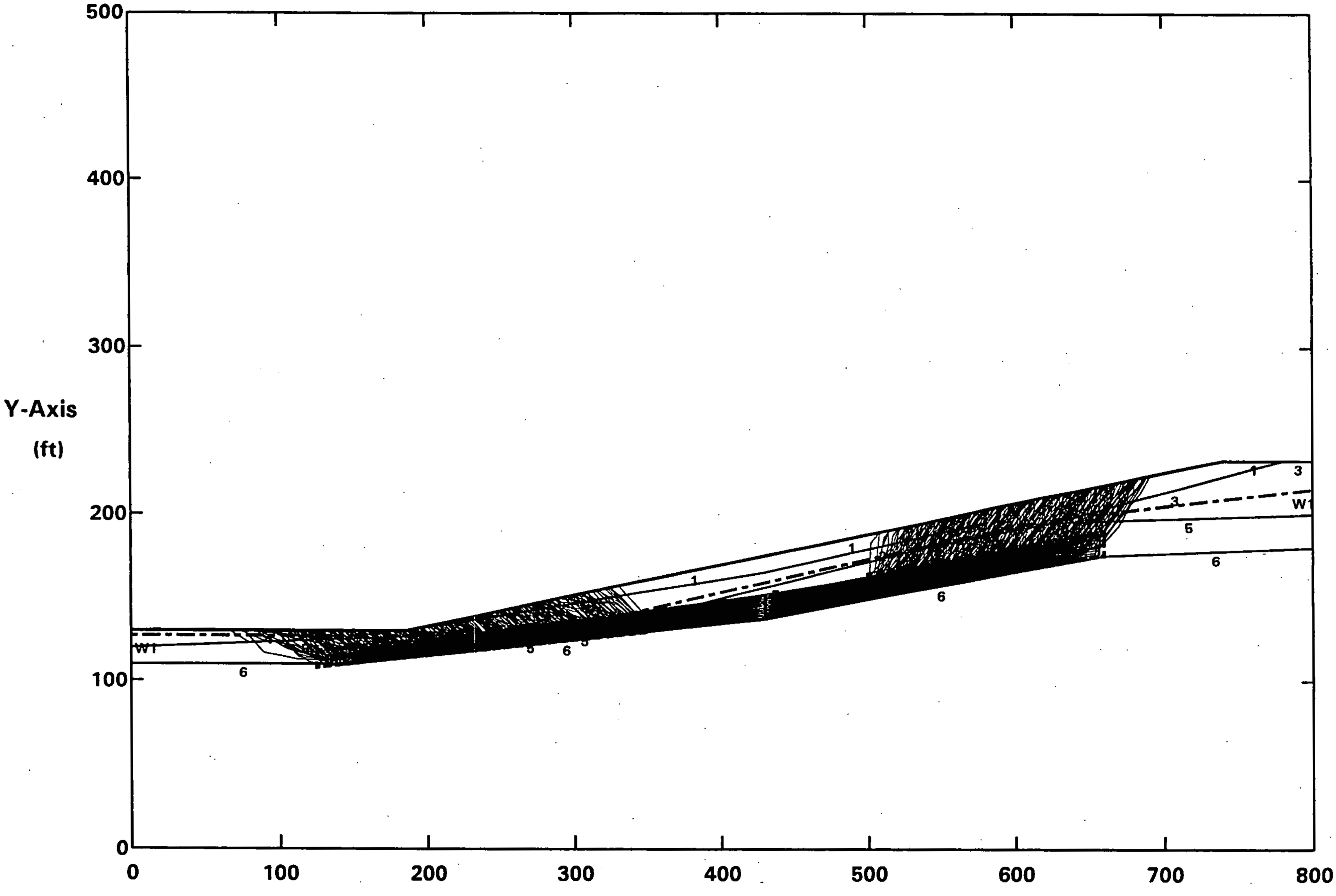


Label	Soil Type No.	Total Unit Wt. (pcf)	Saturated Unit Wt. (pcf)	Cohesion Intercept (psf)	Friction Angle (deg)	Pore Pressure Param.	Pressure Constant (psf)	Piez. Surface No.
WSTE/FIL	1	120	125	50	30	0	0	W1
Qc/SLIDE	2	120	125	0	15	0	0	W1
Qrf	3	120	125	200	30	0	0	W1
Qal	4	125	130	0	33	0	0	W1
WCS	5	120	125	0	15	0	0	W1
UCS	6	125	130	600	30	0	0	W1

PCSTABL5M/SI FSmin = 1.02 X-Axis (ft)
Factors Of Safety Calculated By The Modified Bishop Method

313

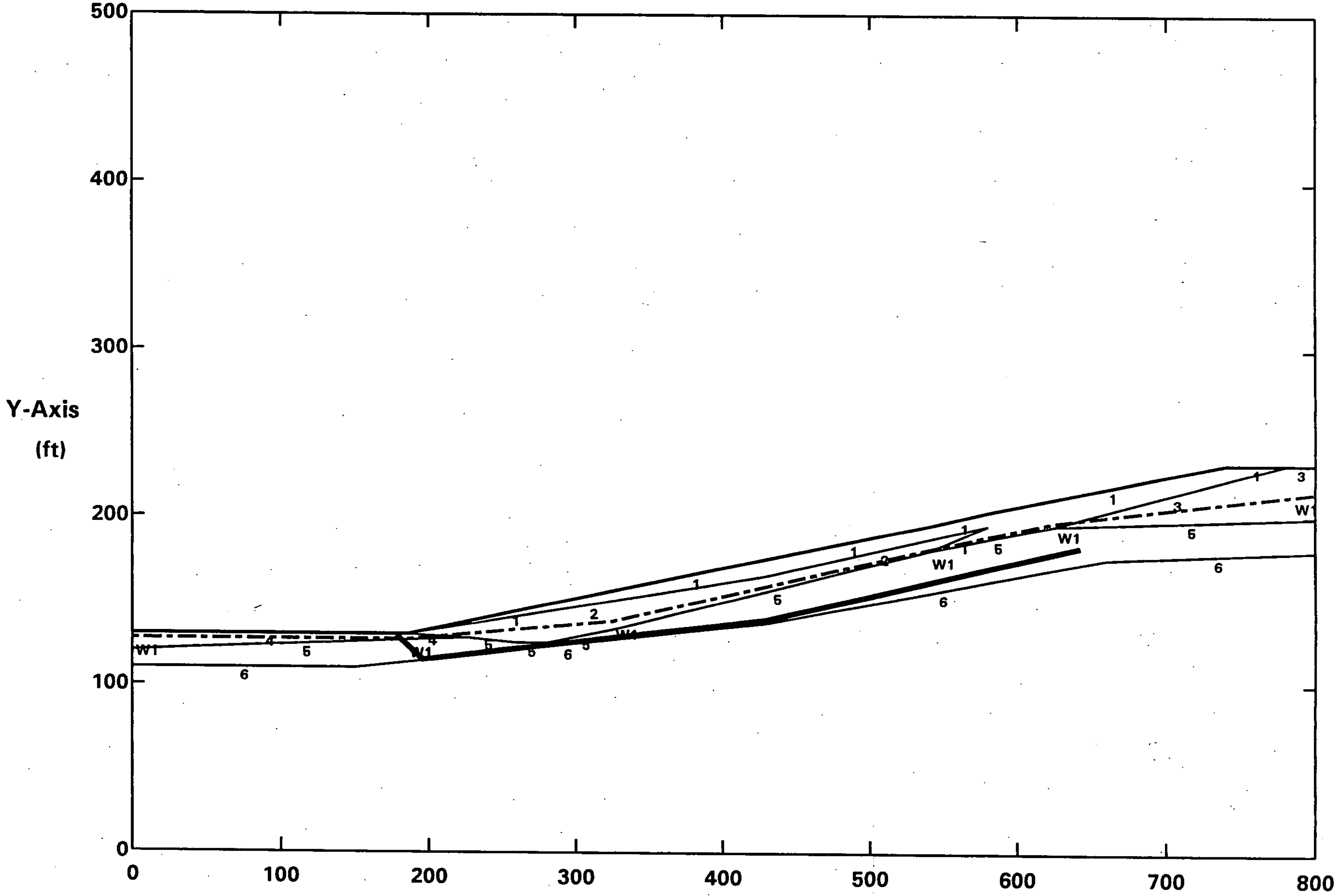
ROCKY FLATS OLF - M&E D 18% GRD - WCS = 15 deg - W/AVEGW - SLIDING BLOCK - 0.06g
All surfaces evaluated. C:DGAS06.PLT By: STAN KLINE 10-24-04 7:59pm



Factors Of Safety Calculated By The Modified Janbu Method

314

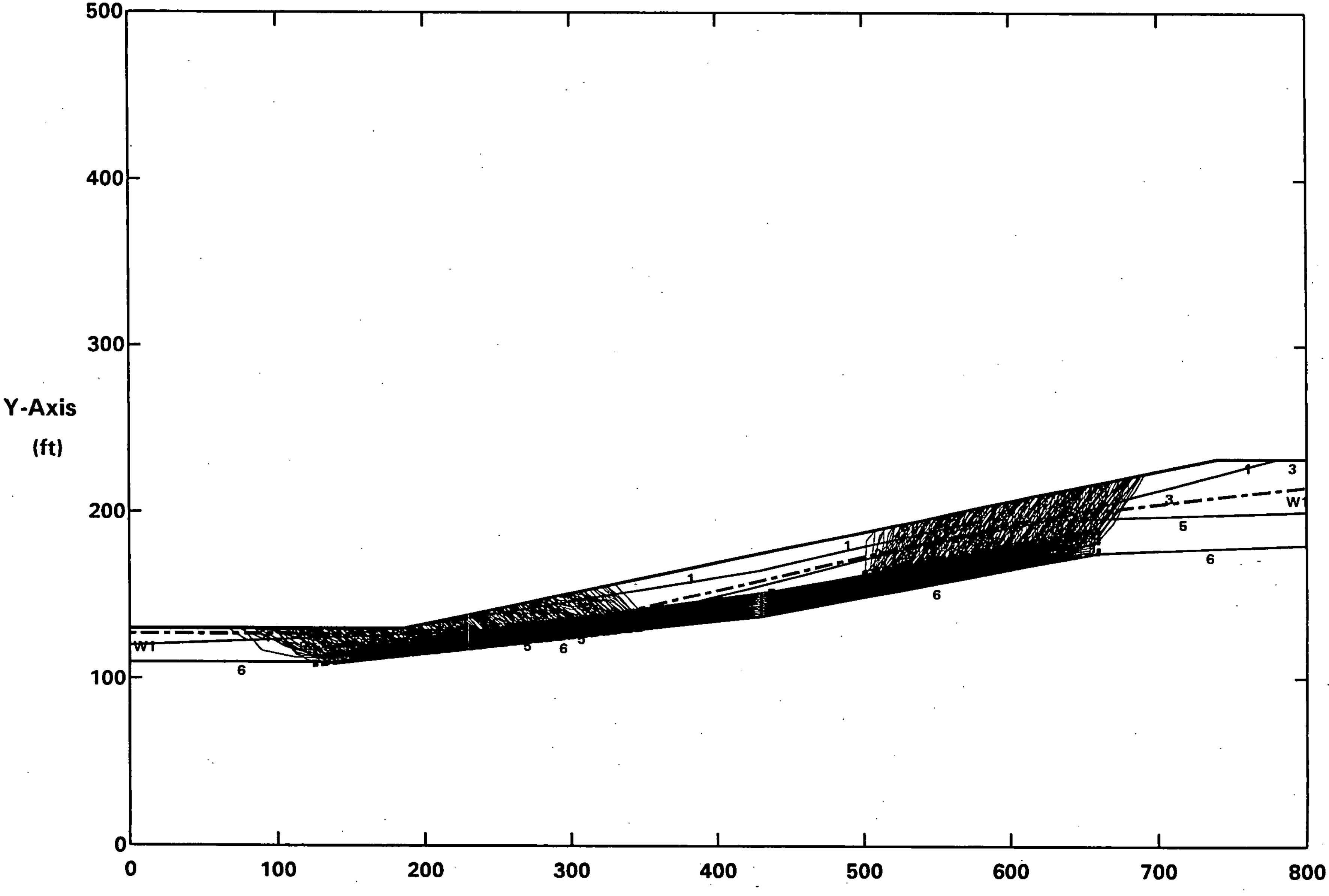
ROCKY FLATS OLF - M&E D 18% GRD - WCS = 15 deg - W/AVEGW - SLIDING BLOCK - 0.06g
Surface #1-DGAS06.OUT. C:DGAS06SP.PLT By: STAN KLINE 10-24-04 11:16pm



PCSTABL5M/SI FS = 0.88 Theta = 9 X-Axis (ft)
Factors Of Safety Calculated By Spencer`s Method of Slices

315

ROCKY FLATS OLF - M&E D 18% GRD - WCS=15 deg - W/AVEGW - SLIDING BLOCK - 0.03g
All surfaces evaluated. C:DGAS03.PLT By: STAN KLINE 10-24-04 7:56pm

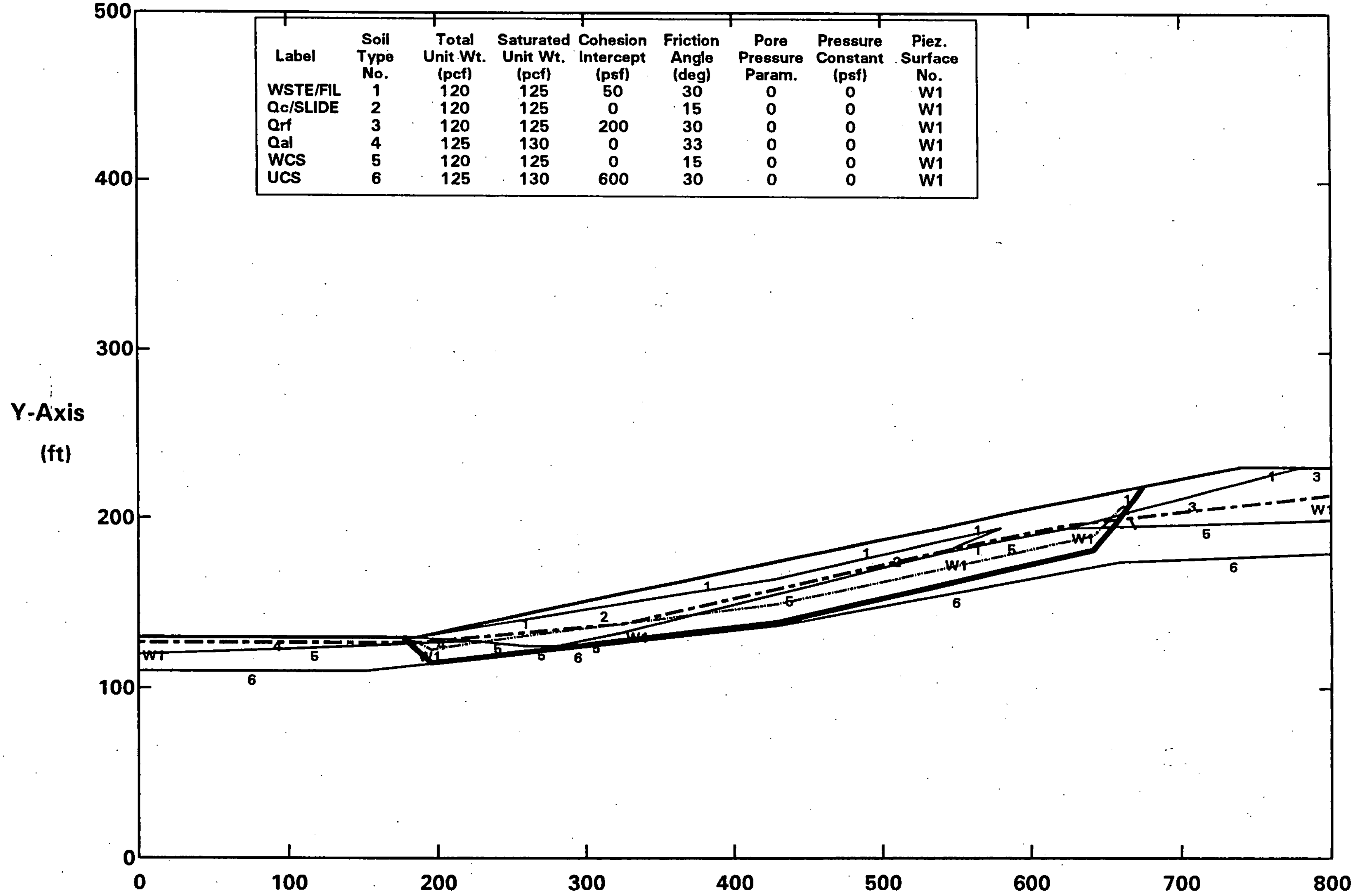


Factors Of Safety Calculated By The Modified Janbu Method

316

ROCKY FLATS OLF - M&E D 18% GRD - WCS = 15 deg - W/AVEGW - SLIDING BLOCK - 0.03g
Surface #1-DGAS03.OUT. C:DGAS03SP.PLT By: STAN KLINE 10-24-04 7:58pm

Label	Soil Type No.	Total Unit Wt. (pcf)	Saturated Unit Wt. (pcf)	Cohesion Intercept (psf)	Friction Angle (deg)	Pore Pressure Param.	Pressure Constant (psf)	Piez. Surface No.
WSTE/FIL	1	120	125	50	30	0	0	W1
Qc/SLIDE	2	120	125	0	15	0	0	W1
Qrf	3	120	125	200	30	0	0	W1
Qal	4	125	130	0	33	0	0	W1
WCS	5	120	125	0	15	0	0	W1
UCS	6	125	130	600	30	0	0	W1

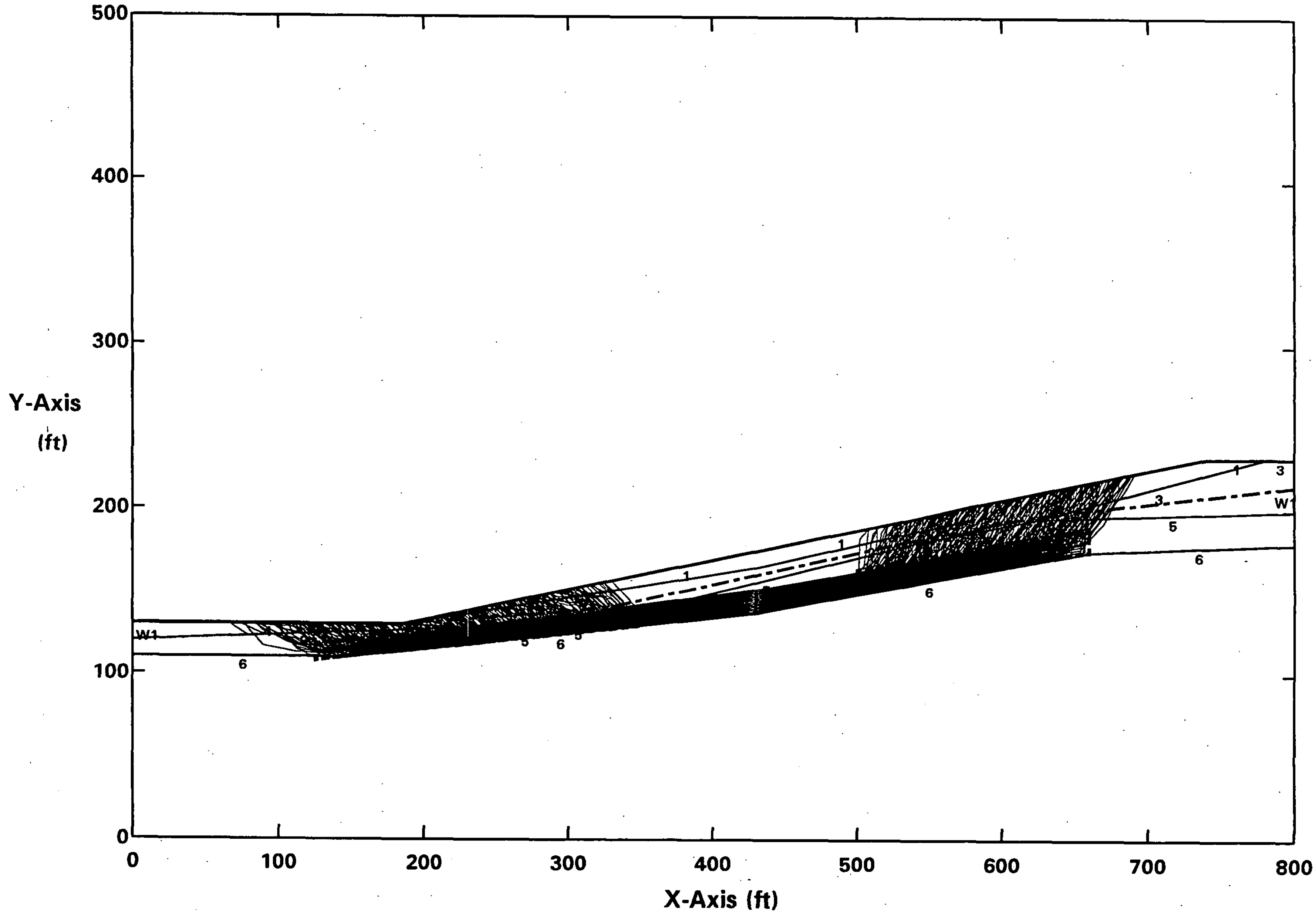


PCSTABL5M/SI FS = 1.02 Theta = 8.87 X-Axis (ft)

Factors Of Safety Calculated By Spencer`s Method of Slices

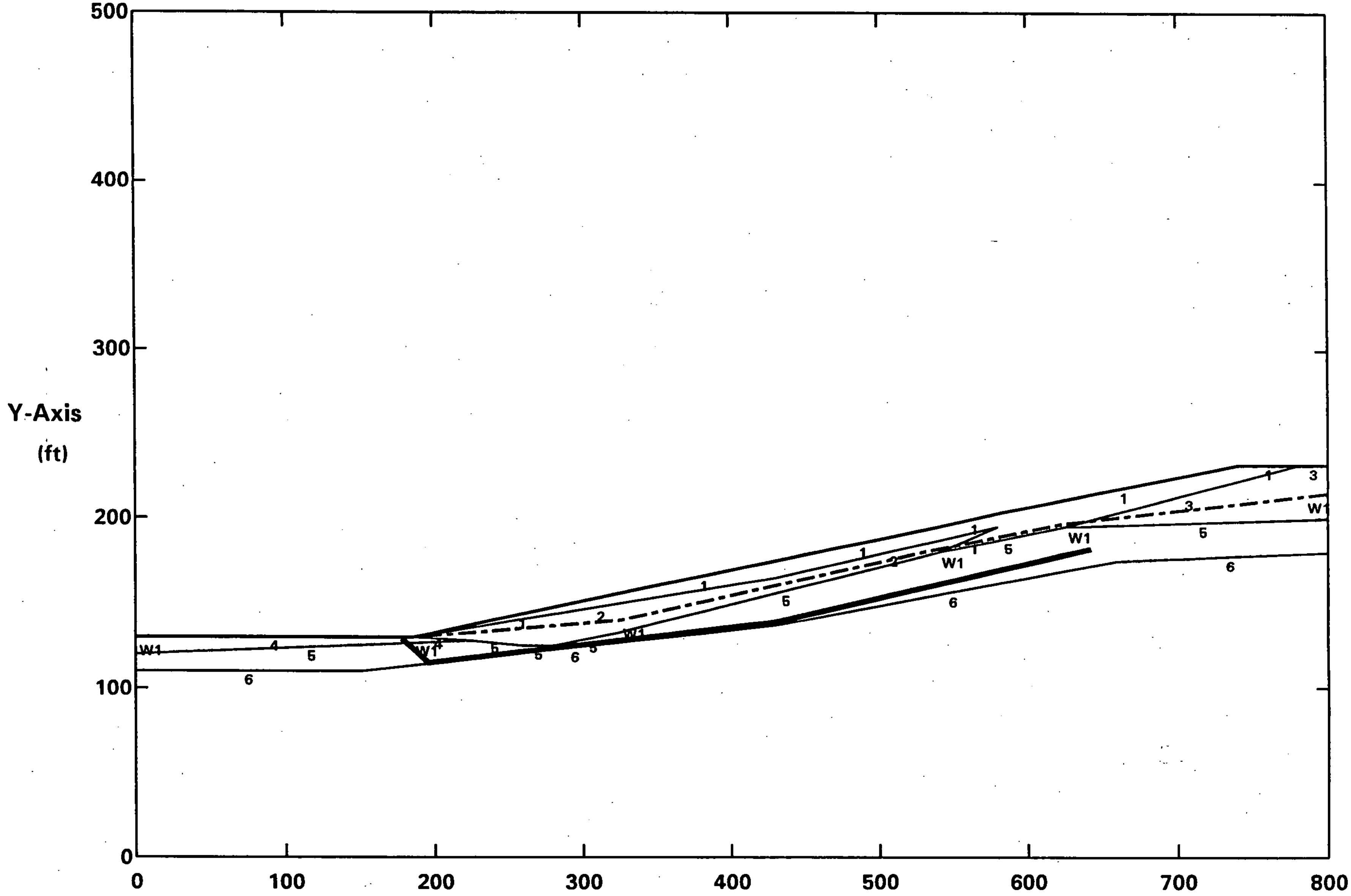
317

ROCKY FLATS OLF - M&E D 18% GRD - WCS= 15 deg - W/HIGHGW - SLIDING BLOCK - 0.06g
All surfaces evaluated. C:DGHS06.PLT By: STAN KLINE 10-24-04 8:38pm



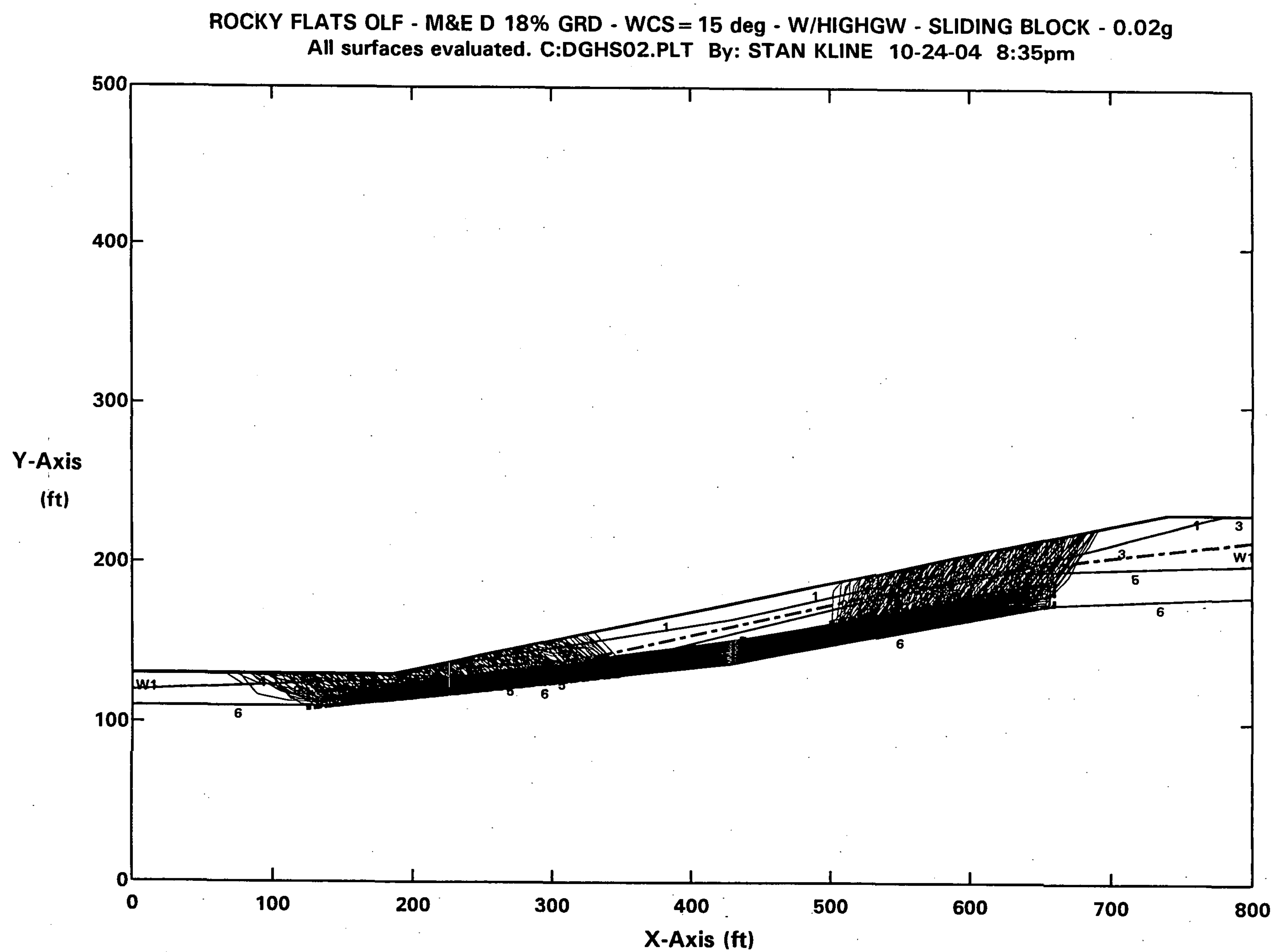
Factors Of Safety Calculated By The Modified Janbu Method

ROCKY FLATS OLF - M&E D 18% GRD - WCS=15 deg - W/HIGHGW - SLIDING BLOCK - 0.06g
Surface #1-DGHS06.OUT. C:DGHS06SP.PLT By: STAN KLINE 10-24-04 8:55pm



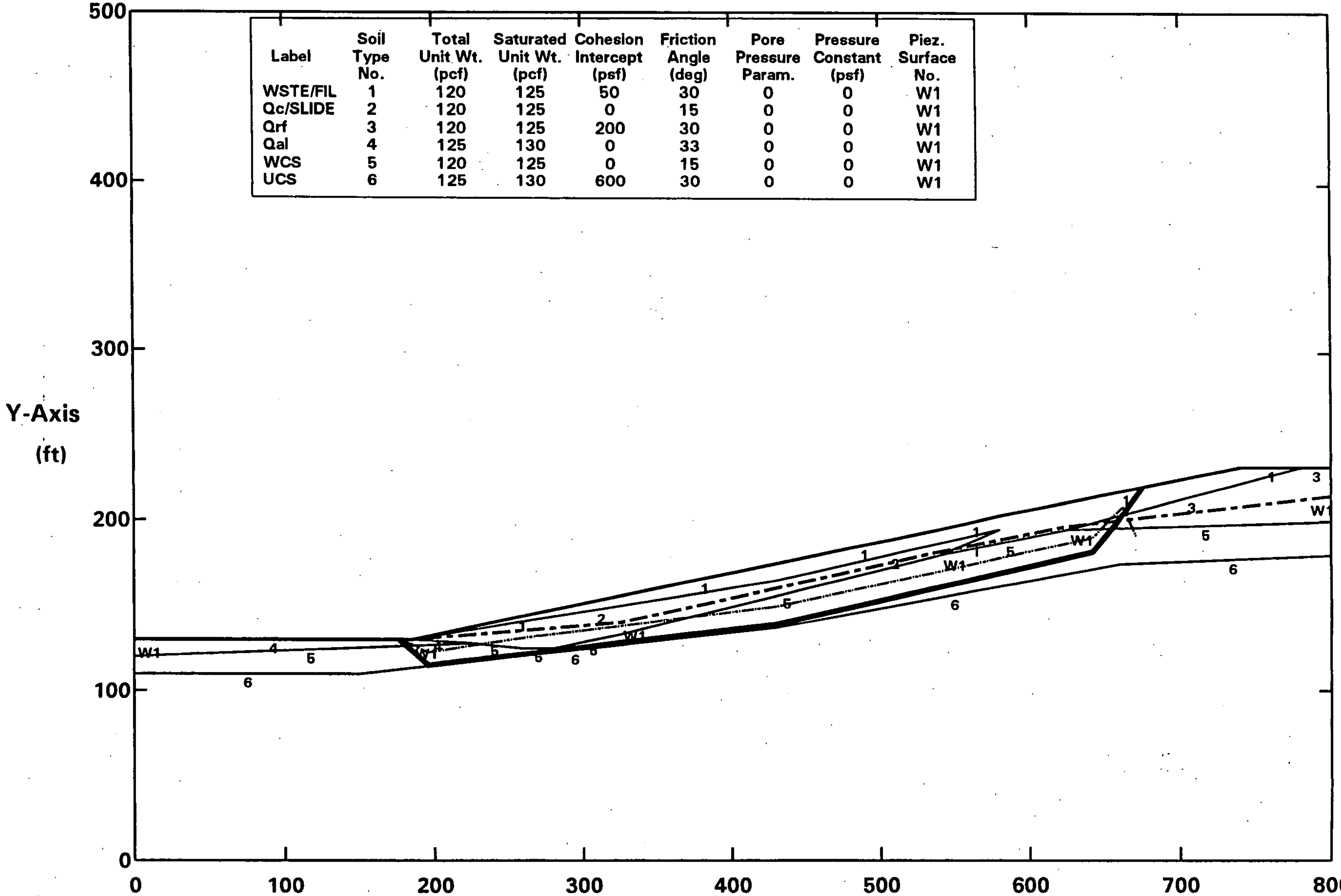
PCSTABL5M/SI FS=0.85 Theta=8.95 X-Axis (ft)
Factors Of Safety Calculated By Spencer`s Method of Slices

319



Factors Of Safety Calculated By The Modified Janbu Method

ROCKY FLATS OLF - M&E D 18% GRD - WCS=15 deg - W/HIGHGW - SLIDING BLOCK - 0.02g
Surface #1-DGHS02.OUT. C:DGHS02SP.PLT By: STAN KLINE 10-24-04 8:37pm



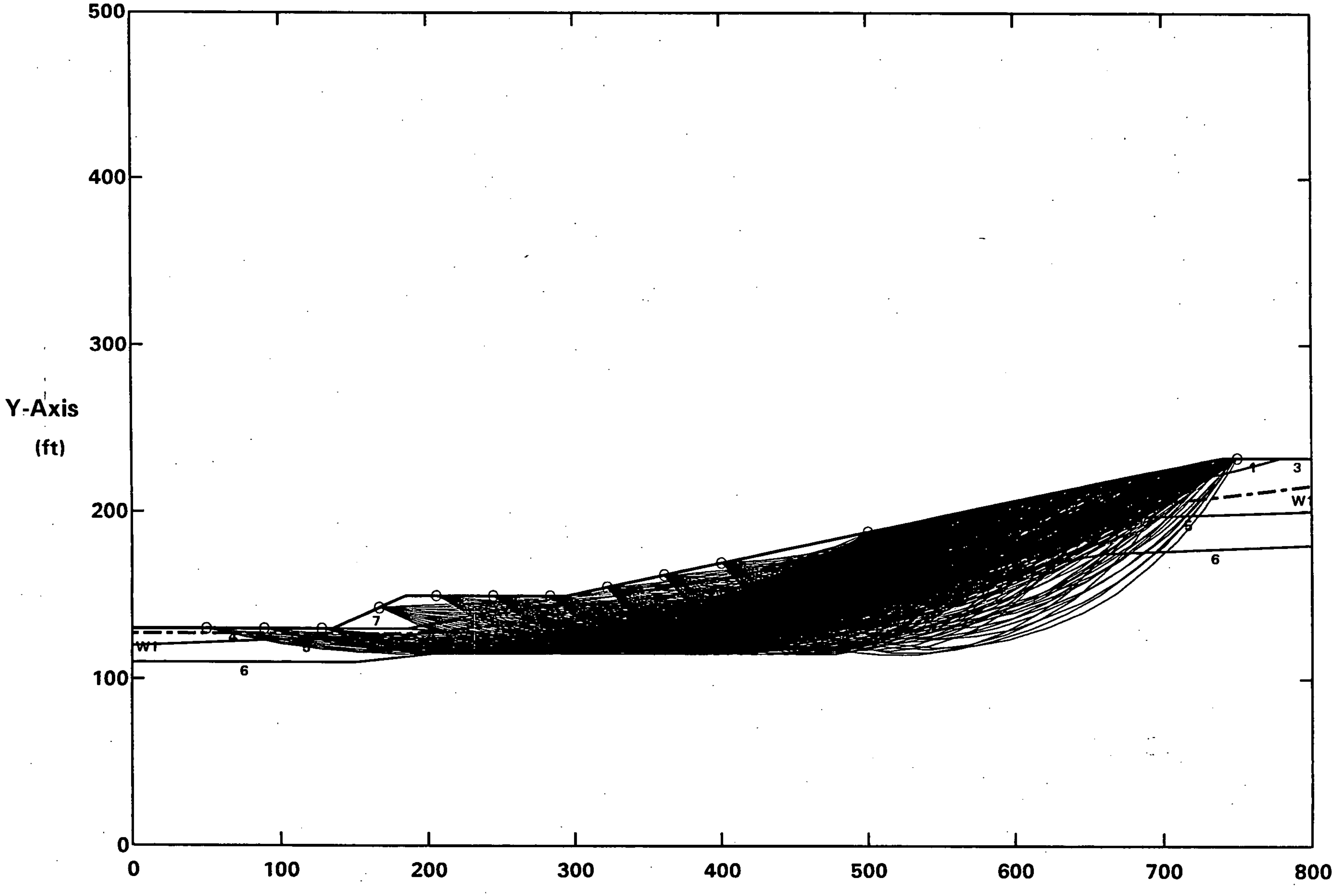
Label	Soil Type No.	Total Unit Wt. (pcf)	Saturated Unit Wt. (pcf)	Cohesion Intercept (psf)	Friction Angle (deg)	Pore Pressure Param.	Pressure Constant (psf)	Piez. Surface No.
WSTE/FIL	1	120	125	50	30	0	0	W1
Qc/SLIDE	2	120	125	0	15	0	0	W1
Qrf	3	120	125	200	30	0	0	W1
Qal	4	125	130	0	33	0	0	W1
WCS	5	120	125	0	15	0	0	W1
UCS	6	125	130	600	30	0	0	W1

PCSTABL5M/SI FS=1.04 Theta=9.03 X-Axis (ft)
Factors Of Safety Calculated By Spencer`s Method of Slices

18% REGRADE WITH BUTTRESS CONDITION

822

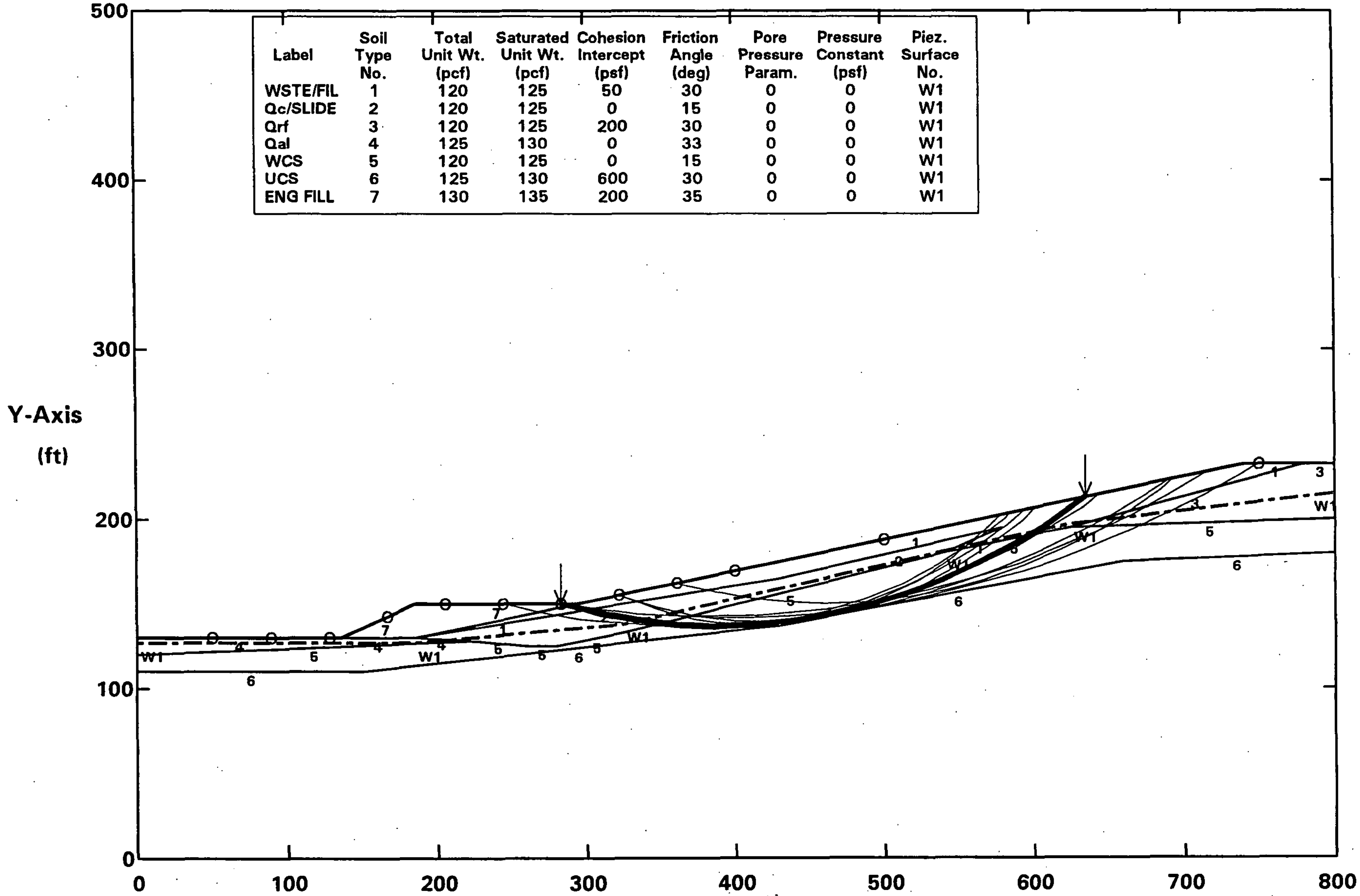
ROCKY FLATS OLF - M&E D 18%W/BM - WCS = 15 deg - W/AVEGW - CIRCULAR - 0.06g
All surfaces evaluated. C:DBAC06.PLT By: STAN KLINE 10-26-04 12:23am



Factors Of Safety Calculated By The Modified Bishop Method

322

ROCKY FLATS OLF - M&E D 18%W/BM - WCS=15 deg - W/AVEGW - CIRCULAR - 0.06g
Ten Most Critical. C:DBAC06.PLT By: STAN KLINE 10-26-04 12:23am



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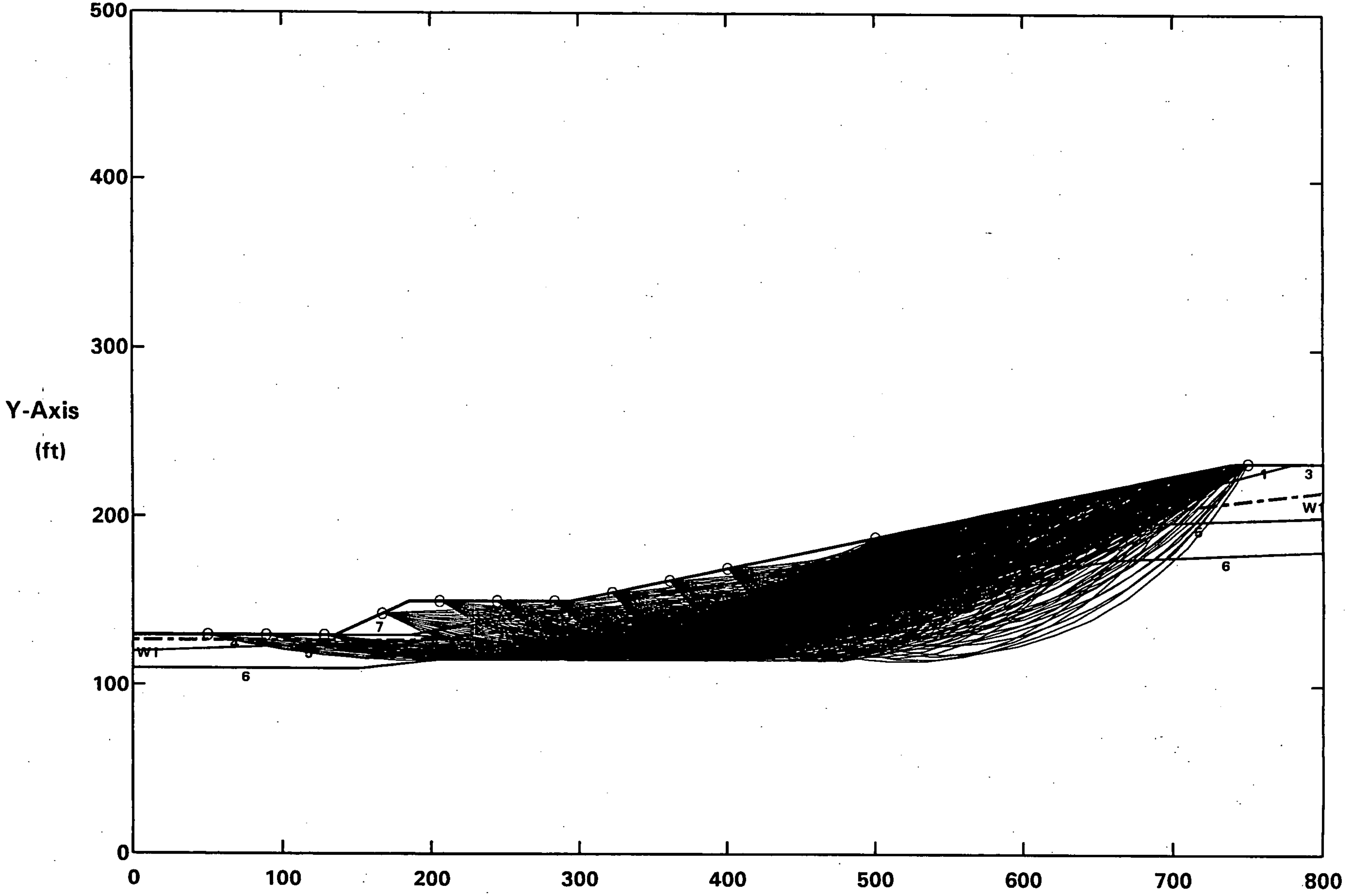
WSTE/FIL	1	120	125	50	30	0	0	W1
Qc/SLIDE	2	120	125	0	15	0	0	W1
Qrf	3	120	125	200	30	0	0	W1
Qal	4	125	130	0	33	0	0	W1
WCS	5	120	125	0	15	0	0	W1
UCS	6	125	130	600	30	0	0	W1
ENG FILL	7	130	135	200	35	0	0	W1

PCSTABL5M/SI FSmin=0.96 X-Axis (ft)
Factors Of Safety Calculated By The Modified Bishop Method

324

ROCKY FLATS OLF - M&E D 18%W/BM - WCS=15 deg - W/AVEGW - CIRCULAR - 0.05g
All surfaces evaluated. C:DBAC05.PLT By: STAN KLINE 10-26-04 12:22am

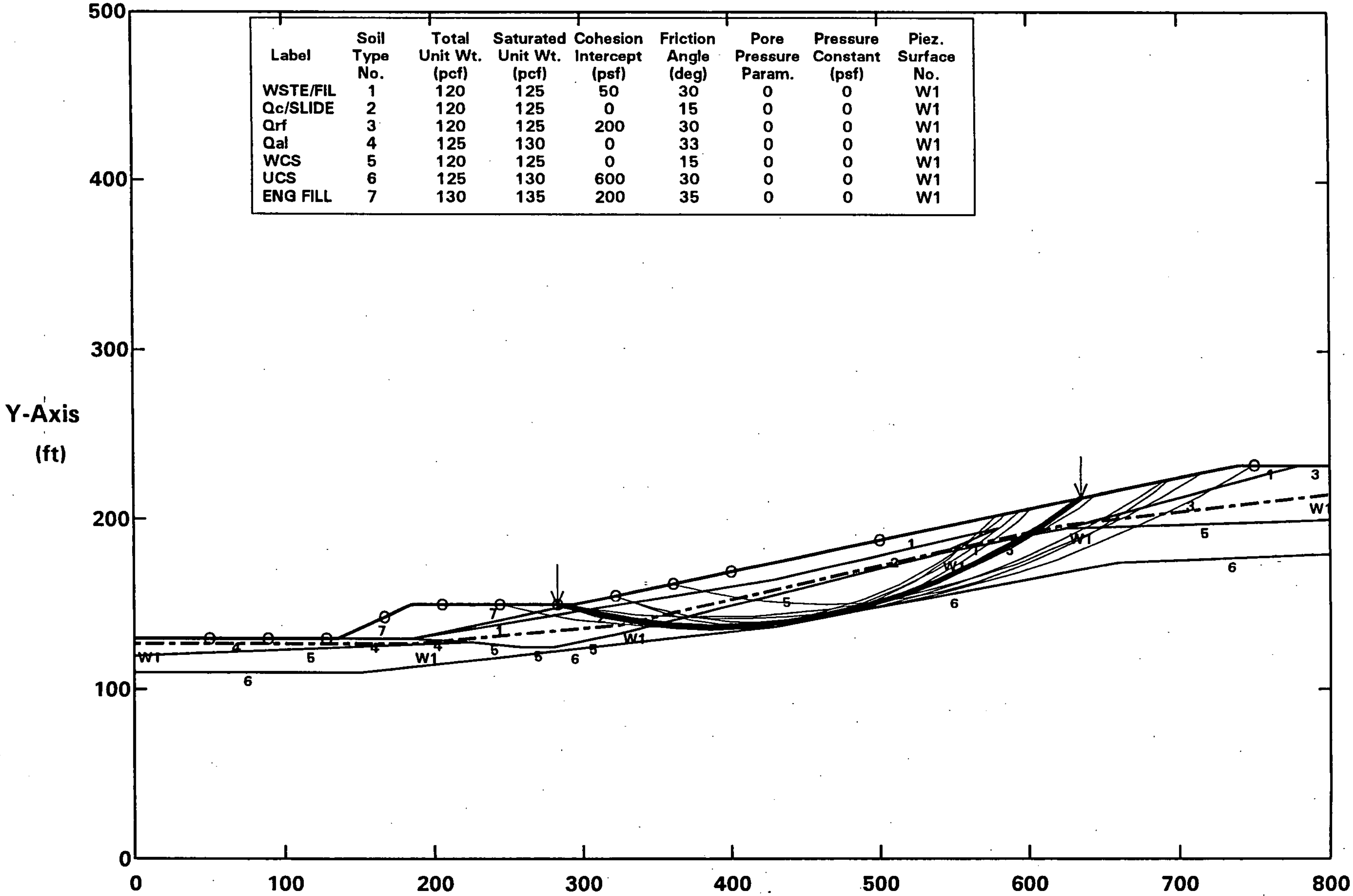


Factors Of Safety Calculated By The Modified Bishop Method

325

ROCKY FLATS OLF - M&E D 18%W/BM - WCS = 15 deg - W/AVEGW - CIRCULAR - 0.05g

Ten Most Critical. C:DBAC05.PLT By: STAN KLINE 10-26-04 12:22am



Label	Soil Type No.	Total Unit Wt. (pcf)	Saturated Unit Wt. (pcf)	Cohesion Intercept (psf)	Friction Angle (deg)	Pore Pressure Param.	Pressure Constant (psf)	Piez. Surface No.
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Qc/SLIDE	2	120	125	0	15	0	0	W1
Qrf	3	120	125	200	30	0	0	W1
Qal	4	125	130	0	33	0	0	W1
WCS	5	120	125	0	15	0	0	W1
UCS	6	125	130	600	30	0	0	W1
ENG FILL	7	130	135	200	35	0	0	W1

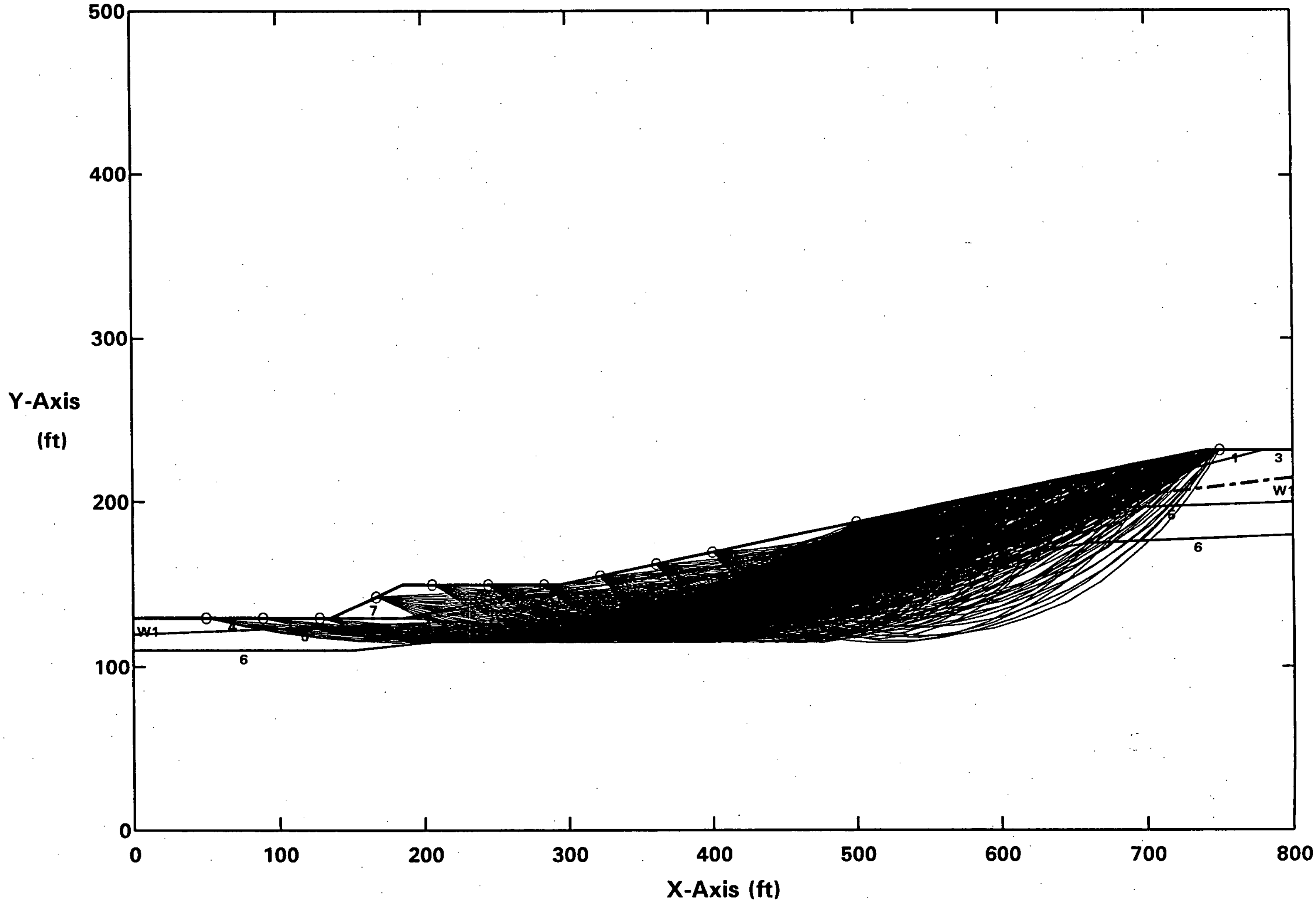
PCSTABL5M/SI FSmin = 1.00 X-Axis (ft)

Factors Of Safety Calculated By The Modified Bishop Method

326

ROCKY FLATS OLF - M&E D 18%W/BM - WCS=15 deg - W/HIGHGW - CIRCULAR - 0.06g

All surfaces evaluated. C:DBHC06.PLT By: STAN KLINE 10-26-04 12:28am



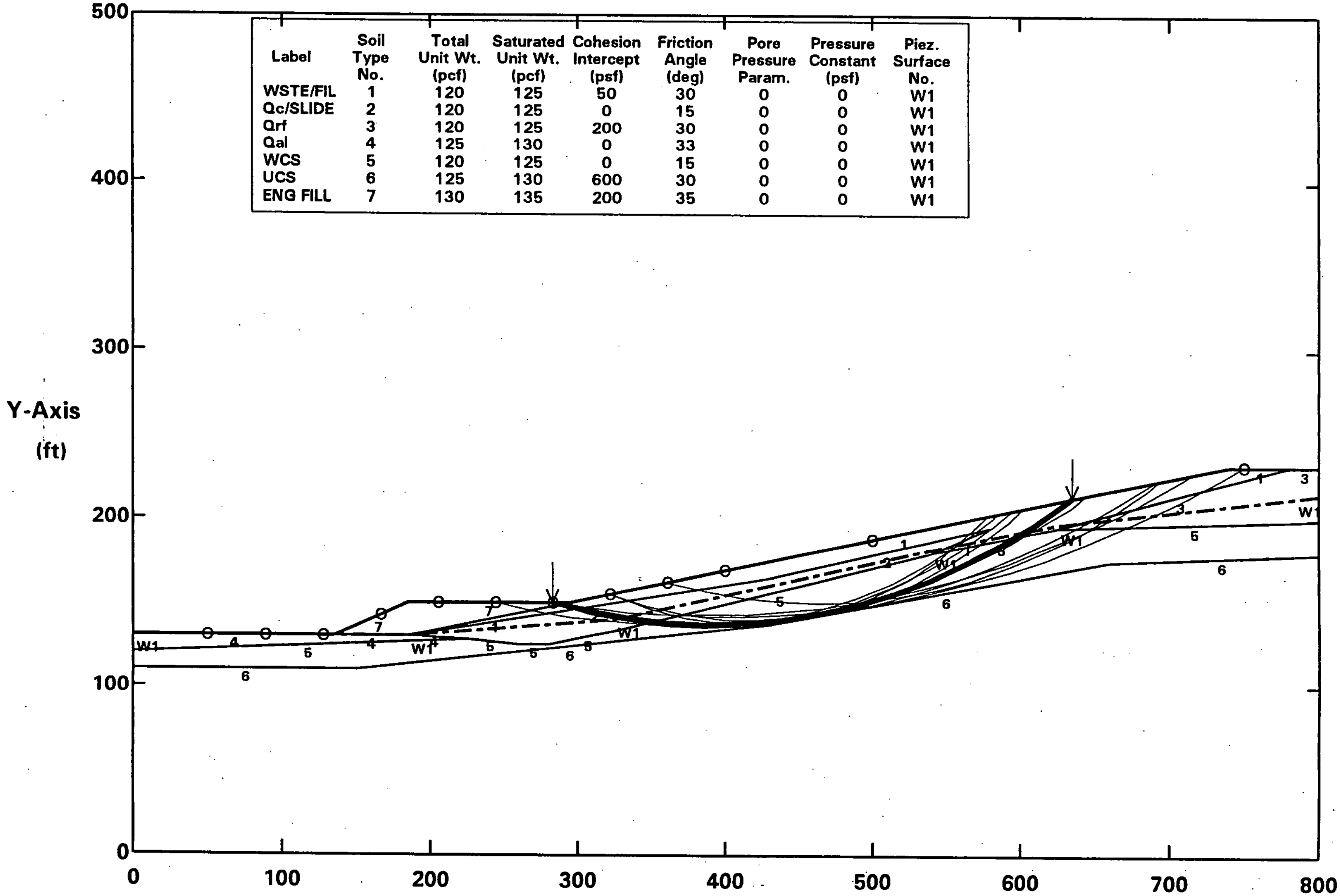
Factors Of Safety Calculated By The Modified Bishop Method

321

ROCKY FLATS OLF - M&E D 18%W/BM - WCS=15 deg - W/HIGHGW - CIRCULAR - 0.06g

Ten Most Critical. C:DBHC06.PLT By: STAN KLINE 10-26-04 12:28am

Label	Soil Type No.	Total Unit Wt. (pcf)	Saturated Unit Wt. (pcf)	Cohesion Intercept (psf)	Friction Angle (deg)	Pore Pressure Param.	Pressure Constant (psf)	Piez. Surface No.
WSTE/FIL	1	120	125	50	30	0	0	W1
Qc/SLIDE	2	120	125	0	15	0	0	W1
Qrf	3	120	125	200	30	0	0	W1
Qal	4	125	130	0	33	0	0	W1
WCS	5	120	125	0	15	0	0	W1
UCS	6	125	130	600	30	0	0	W1
ENG FILL	7	130	135	200	35	0	0	W1

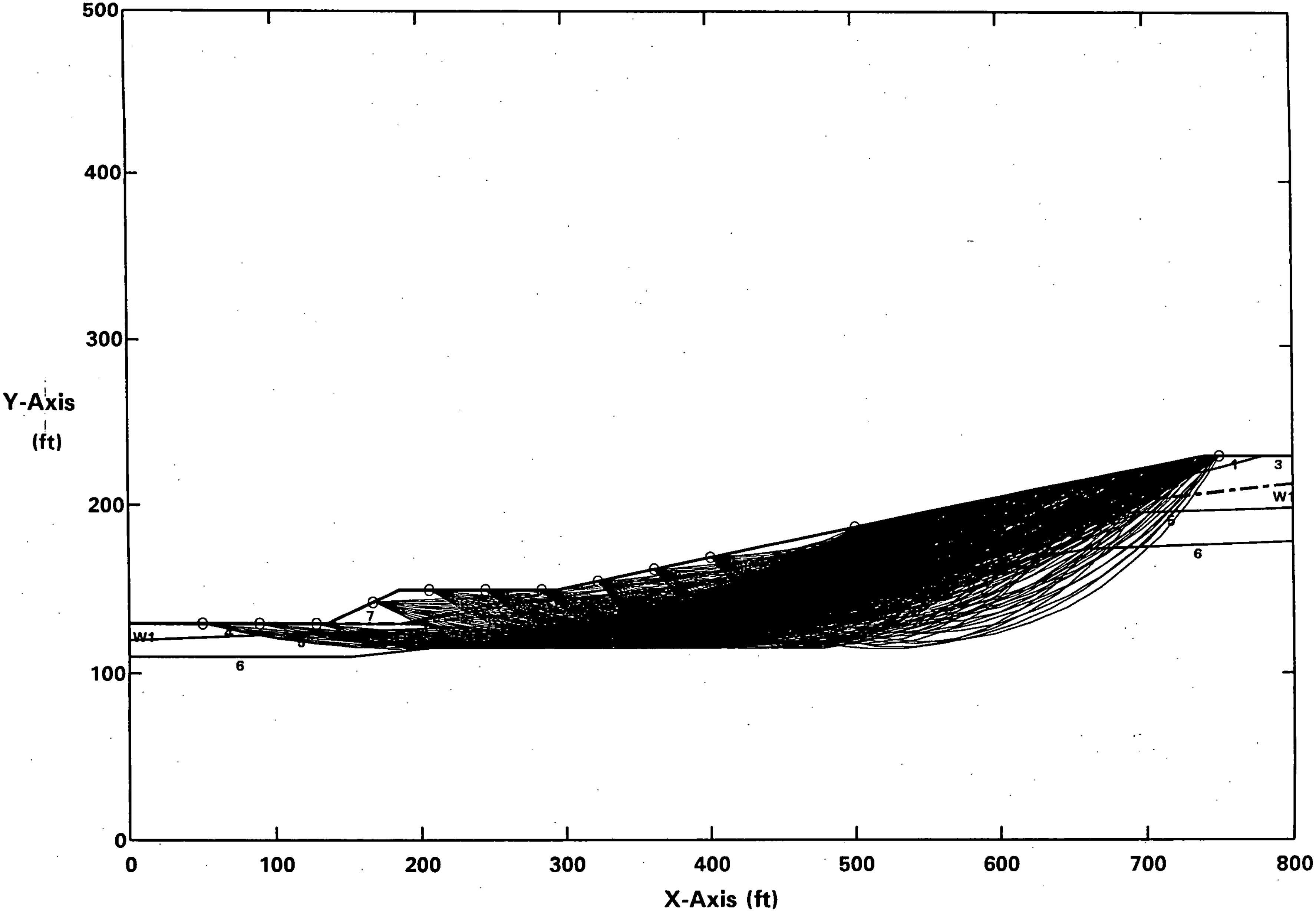


PCSTABL5M/SI FSmin=0.93 X-Axis (ft)

Factors Of Safety Calculated By The Modified Bishop Method

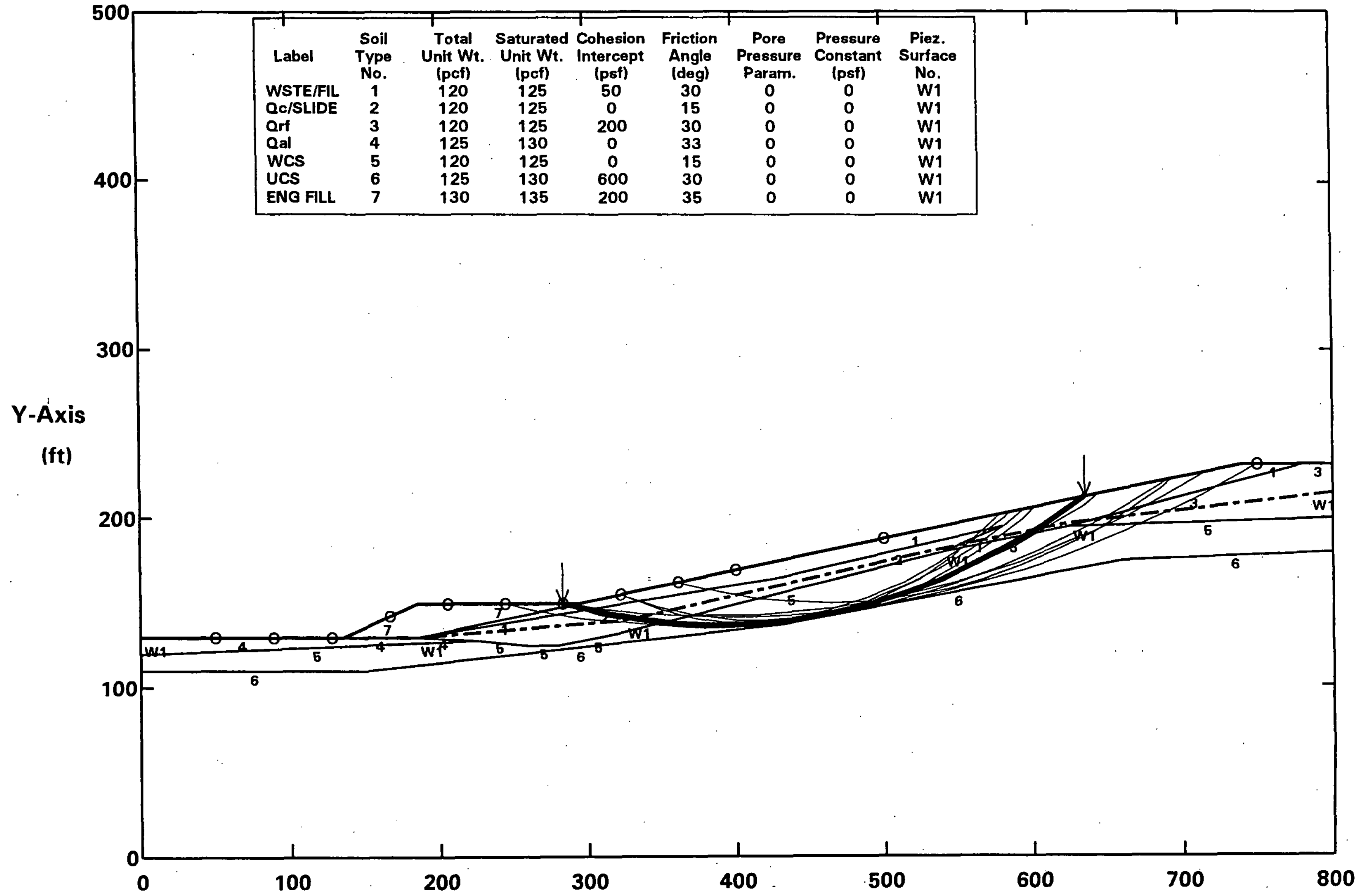
228

ROCKY FLATS OLF - M&E D 18%W/BM - WCS=15 deg - W/HIGHGW - CIRCULAR - 0.04g
All surfaces evaluated. C:DBHC04.PLT By: STAN KLINE 10-26-04 12:27am



Factors Of Safety Calculated By The Modified Bishop Method

ROCKY FLATS OLF - M&E D 18%W/BM - WCS = 15 deg - W/HIGHGW - CIRCULAR - 0.04g
Ten Most Critical. C:DBHC04.PLT By: STAN KLINE 10-26-04 12:27am

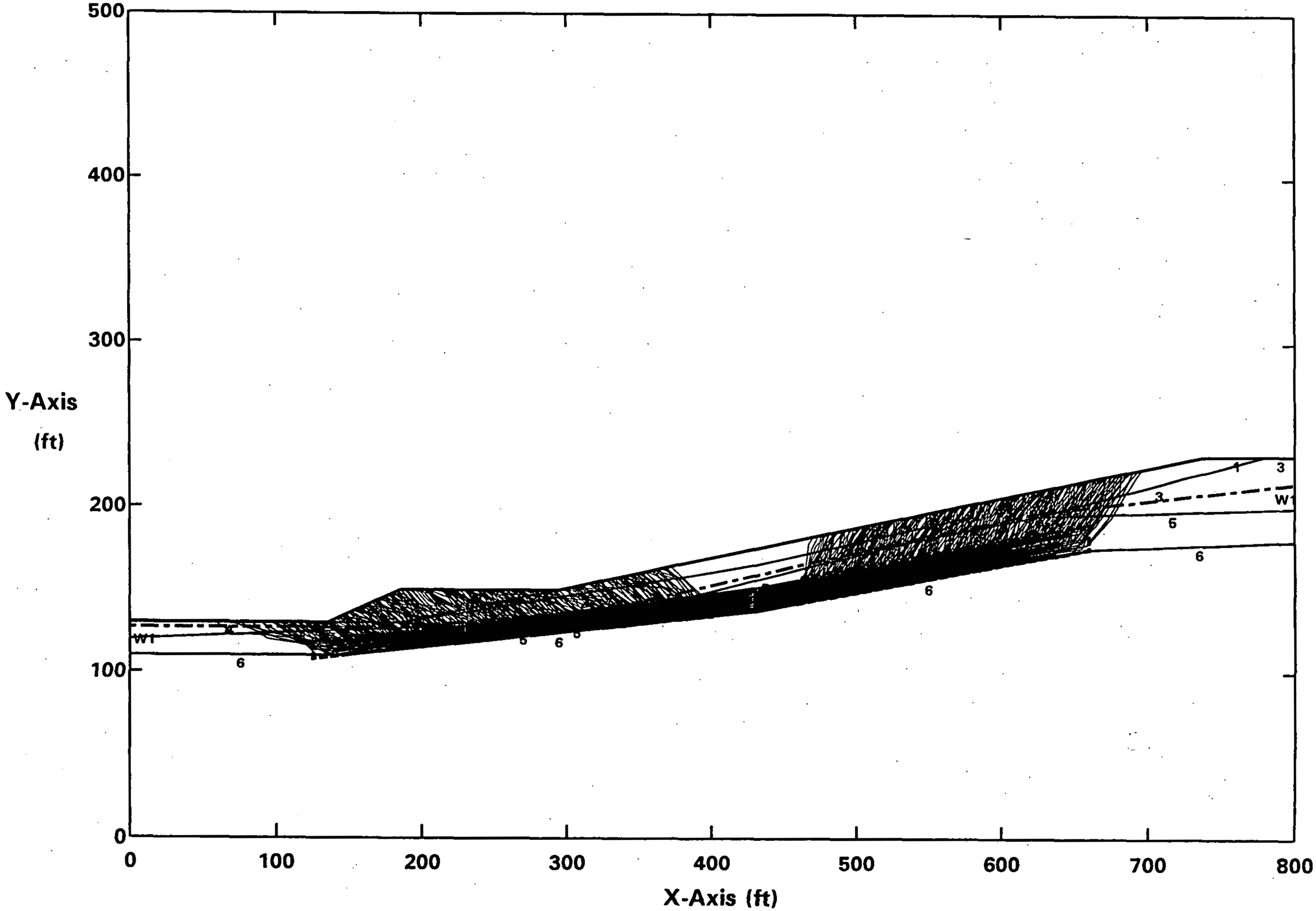


Label	Soil Type No.	Total Unit Wt. (pcf)	Saturated Unit Wt. (pcf)	Cohesion Intercept (psf)	Friction Angle (deg)	Pore Pressure Param.	Pressure Constant (psf)	Piez. Surface No.
WSTE/FIL	1	120	125	50	30	0	0	W1
Qc/SLIDE	2	120	125	0	15	0	0	W1
Qrf	3	120	125	200	30	0	0	W1
Qal	4	125	130	0	33	0	0	W1
WCS	5	120	125	0	15	0	0	W1
UCS	6	125	130	600	30	0	0	W1
ENG FILL	7	130	135	200	35	0	0	W1

PCSTABL5M/SI FSmin = 1.02 X-Axis (ft)
Factors Of Safety Calculated By The Modified Bishop Method

320

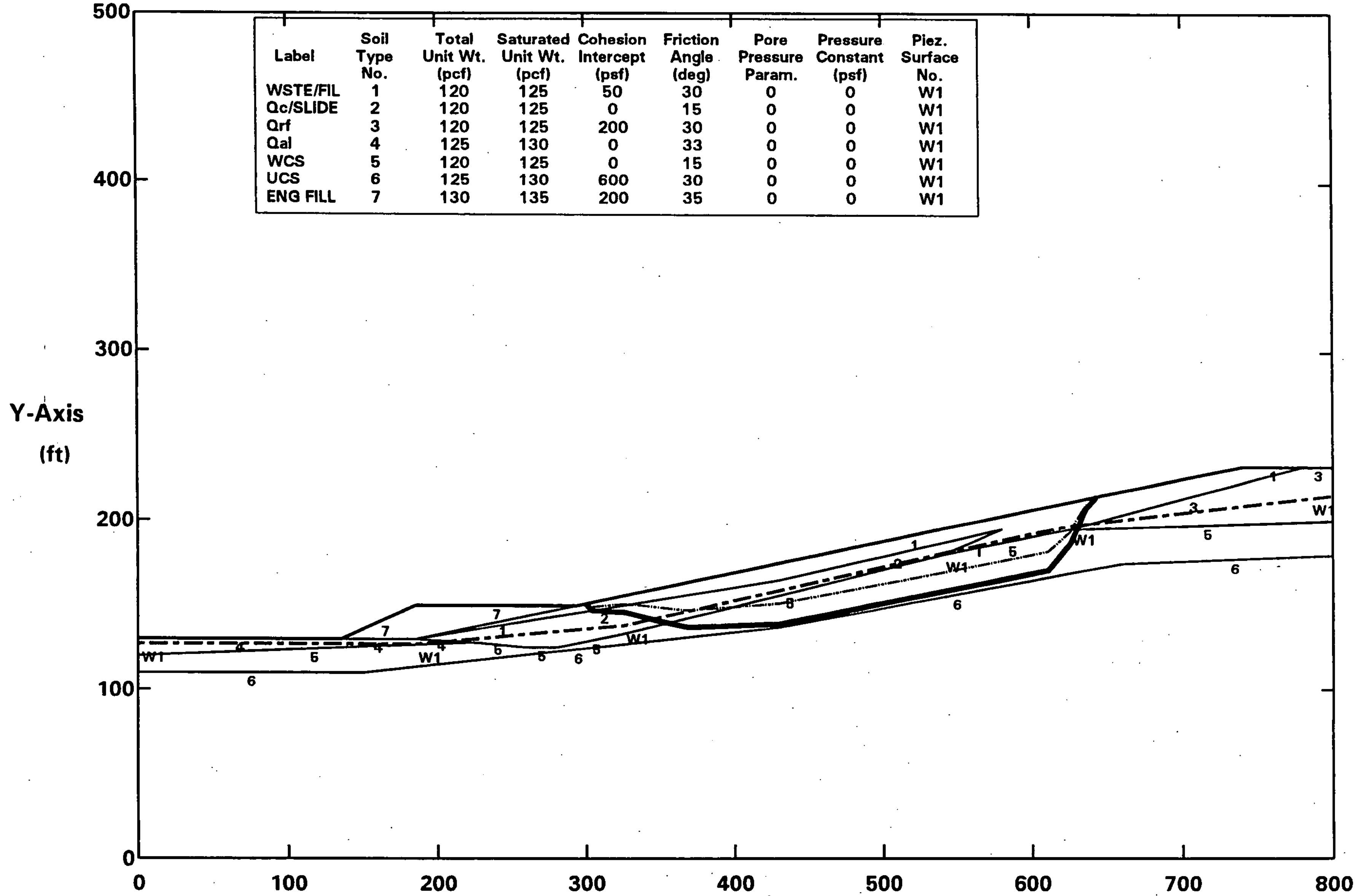
ROCKY FLATS OLF - M&E D 18%W/BM - WCS = 15 deg - W/AVEGW - SLIDING BLOCK - 0.06g
All surfaces evaluated. C:DBAS06.PLT By: STAN KLINE 10-24-04 8:09pm



Factors Of Safety Calculated By The Modified Janbu Method

331

ROCKY FLATS OLF - M&E D 18%W/BM - WCS=15 deg - W/AVEGW - SLIDING BLOCK - 0.06g
Surface #1-DBAS06.OUT. C:DBAS06SP.PLT By: STAN KLINE 10-24-04 8:13pm

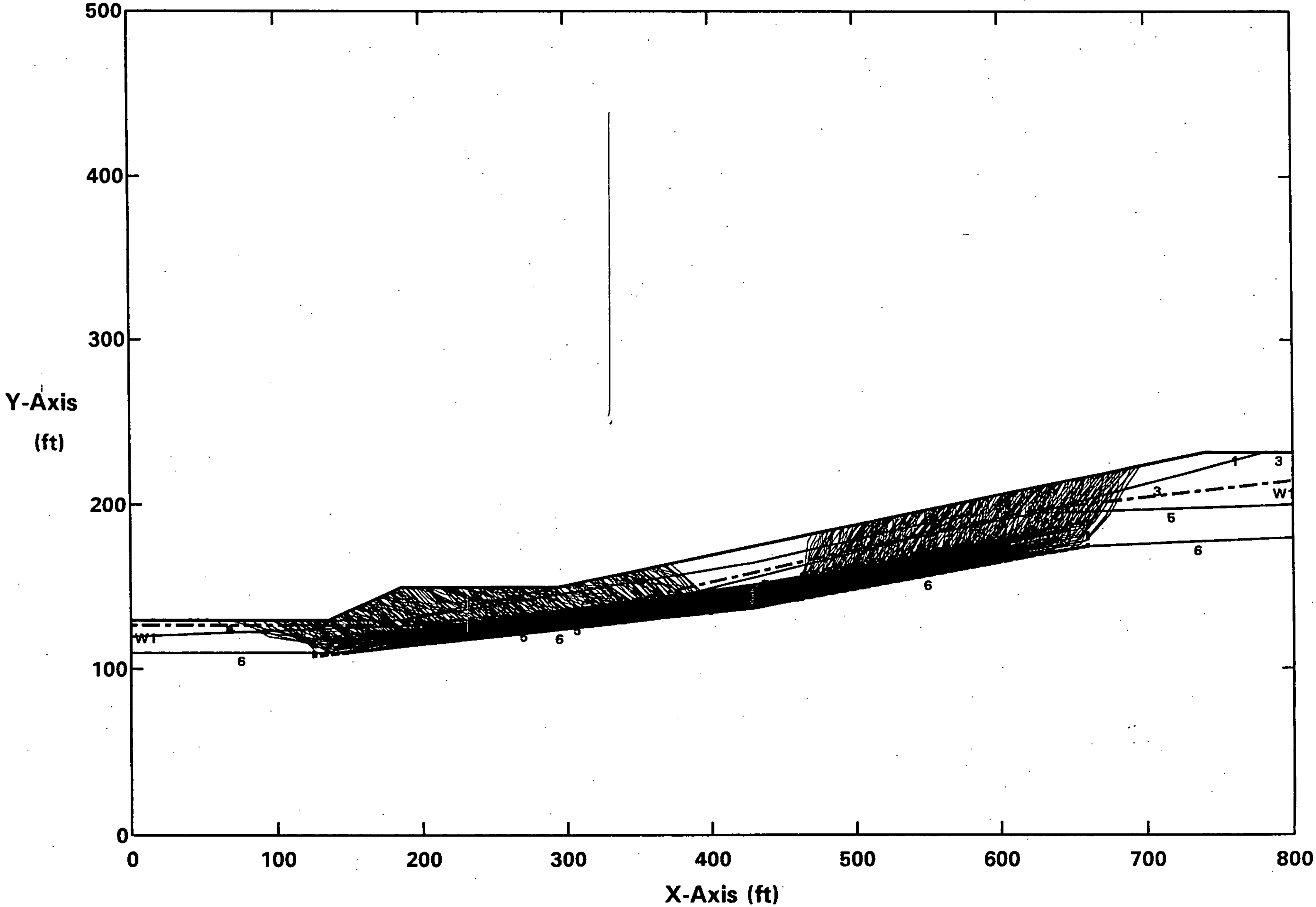


Label	Soil Type No.	Total Unit Wt. (pcf)	Saturated Unit Wt. (pcf)	Cohesion Intercept (psf)	Friction Angle (deg)	Pore Pressure Param.	Pressure Constant (psf)	Piez. Surface No.
WSTE/FIL	1	120	125	50	30	0	0	W1
Qc/SLIDE	2	120	125	0	15	0	0	W1
Qrf	3	120	125	200	30	0	0	W1
Qal	4	125	130	0	33	0	0	W1
WCS	5	120	125	0	15	0	0	W1
UCS	6	125	130	600	30	0	0	W1
ENG FILL	7	130	135	200	35	0	0	W1

PCSTABL5M/SI FS=0.94 Theta=7.93 X-Axis (ft)
Factors Of Safety Calculated By Spencer`s Method of Slices

332

ROCKY FLATS OLF - M&E D 18%W/BM - WCS = 15 deg - W/AVEGW - SLIDING BLOCK - 0.04g
All surfaces evaluated. C:DBAS04.PLT By: STAN KLINE 10-24-04 8:06pm

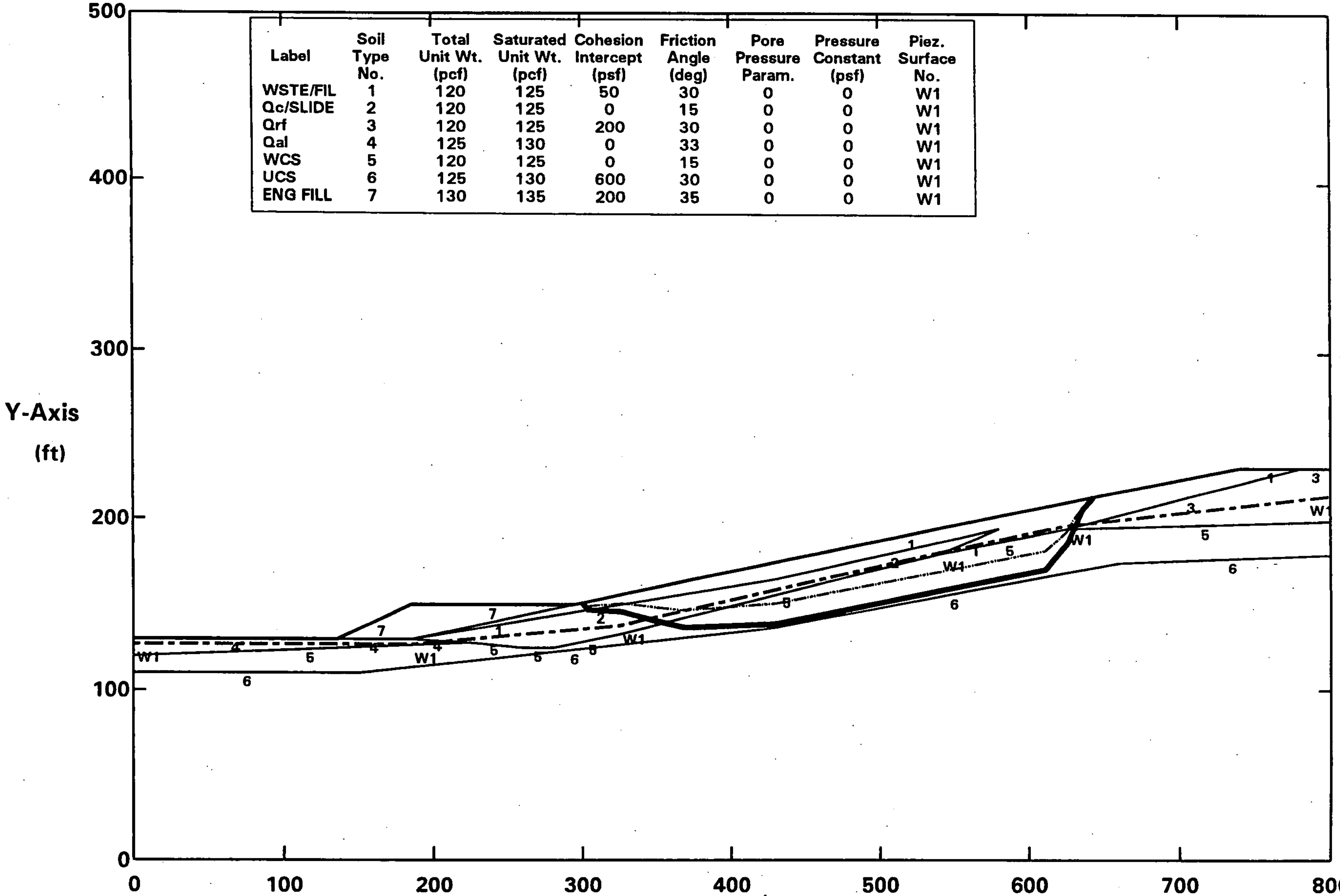


Factors Of Safety Calculated By The Modified Janbu Method

333

ROCKY FLATS OLF - M&E D 18%W/BM - WCS=15 deg - W/AVEGW - SLIDING BLOCK - 0.04g
Surface #1-DBAS04.OUT. C:DBAS04SP.PLT By: STAN KLINE 10-24-04 8:08pm

Label	Soil Type No.	Total Unit Wt. (pcf)	Saturated Unit Wt. (pcf)	Cohesion Intercept (psf)	Friction Angle (deg)	Pore Pressure Param.	Pressure Constant (psf)	Piez. Surface No.
WSTE/FIL	1	120	125	50	30	0	0	W1
Qc/SLIDE	2	120	125	0	15	0	0	W1
Qrf	3	120	125	200	30	0	0	W1
Qal	4	125	130	0	33	0	0	W1
WCS	5	120	125	0	15	0	0	W1
UCS	6	125	130	600	30	0	0	W1
ENG FILL	7	130	135	200	35	0	0	W1



PCSTABL5M/SI FS=1.03 Theta=8.15 X-Axis (ft)
Factors Of Safety Calculated By Spencer`s Method of Slices

INFINITE SLOPE STABILITY - SIMPLIFIED APPROACH

Part I - COHESIVE AND FRICTIONAL SOIL SLOPES

(Ref. USACE [1970), EM 1110-2-1902)

Input Data

γ_{sat}	125	Total saturated unit weight of soil (pcf)
γ_w	62.4	Unit weight of water (62.4 pcf)
γ'	62.6	Submerged unit weight of soil (pcf)
α	10	Angle between seepage flow line and embankment slope
β	10.2	Angle of inclination of embankment slope with horizontal
b	5.6	Horizontal to vertical slope ratio [or cot(β) = H:V]
ϕ	30	Angle of internal friction of soil (degrees)
c	50	Cohesion intercept of soil (psf)
Ψ	0.06	Seismic coefficient
b'	5.2	Cotangent of "seismic-equivalent" angle of inclination of embankment slope w/ hor.
β'	10.9	Seismic-equivalent angle of inclination of embankment slope with horizontal (degrees)
		Additional Input for Cohesive Soil Case
z	5.0	Depth to potential slip surface (feet)
d_w	0.0	Depth to ground water surface parallel to slope (feet)

Output Data

FS	Computed static stability factor of safety
PSFS	Computed pseudo-static stability factor of safety, for seismic coefficient Ψ
K_y	Yield acceleration

Static or Pseudo-Static Stability and Yield Acceleration (Ref. Matasovic [1989)

FS	$= \{c/(\gamma\, z \cos^2\beta) + \tan\phi\, [1 - \gamma_w (z - d_w)/(\gamma\, z)] - \Psi \tan\beta \tan\phi\}/ (\Psi + \tan\beta)$
$\mathbf{K_y}$	$= \{c/(\gamma\, z \cos^2\beta) + \tan\phi\, [1 - \gamma_w (z - d_w)/(\gamma\, z)] - \tan\beta\}/ (1 + \tan\beta * \tan\phi)$

FS =	2.07
PSFS =	1.52
$\mathbf{K_y}$ **=**	0.17

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APPENDIX F

DEFORMATION ANALYSIS

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APPENDIX F

ANALYSIS OF SEISMICALLY-INDUCED PERMANENT DISPLACEMENT OF LANDFILL SLOPES BY THE MAKDISI AND SEED PROCEDURE

INTRODUCTION

Background: A common procedure for estimating seismically-induced permanent displacements was developed by F. Makdisi and H.B. Seed (1978). This procedure has been extensively used to assess the seismic performance of earthfill slopes during earthquakes using the concept of accumulation of permanent slope displacements from corresponding pulses of strong earthquake loading, as initially proposed by Newmark (1965) for rigid-perfectly plastic materials, but subsequently modified by Makdisi and Seed to simulate the dynamic response of earthfill structures.

Design Philosophy: The engineering community generally recognizes that some permanent displacement or deformation of large fills may occur during major earthquake events, and that designing fills to completely prevent permanent displacements is typically impractical, if not impossible. Rational seismic design criteria consist of limiting displacements to levels which are likely to be tolerable. The use of such a deformation analysis is widely accepted for dams, embankments, landfills, in all of the highest seismicity regions of the country.

Advantages of the Method: It is a simple, yet rational approach, offering a significant improvement over conventional pseudo-static approach because it takes into account factors such as the predominant period and the effective peak horizontal acceleration of a potential sliding mass being analyzed. It also accounts for the variation in effective peak horizontal acceleration with depth and it is considered to give more accurate permanent displacement estimates than the Newmark (1965) method. Available simplified design curves were developed to calculate permanent displacement of earthfill slopes in the range of 100 to 200 feet for different earthquake magnitudes, but it is generally believed to be applicable to higher slopes. The simplified design curves were developed from more rigorous dynamic response analyses at embankments and slopes.

Criteria that had previously been used in engineering practice (namely seismic coefficient (K) and recommended pseudo-static factor of safety for conventional pseudo-static analysis were summarized in Figure F1 (from California Division of Mines and Geology, Special Publication 117, dated 1997). Computation of seismically-induced permanent displacement as originally proposed by Newmark (1965) is conceptually summarized in Figure F2 (from Hynes and Franklin of the USACE, 1984).

Assumptions: It assumes that failure occurs on a well-defined slip surface and that the material behaves near-elastically at stress levels below failure, but develops a perfectly plastic behavior above yield. It involves a number of simplifying assumptions which may lead to some somewhat conservative results. It was developed and calibrated based on the use of equivalent-linear strain-dependent dynamic soil parameters (shear modulus and damping ratio) and the dynamic finite element analysis of slopes. Development of this procedure is conceptually summarized on Figures F3 through F9, from initial research by Makdisi and Seed of University of California at Berkeley, 1978; from supplementary research by Hynes and Franklin of the USACE, 1984 for the analysis of earthfill slopes and embankment dams; and from seismic response studies for several geologic site conditions by Seed and Idriss, 1982.

Applications and Limitations: It is primarily applicable to materials such as compacted cohesive clay and dry sands and dense sands, which are expected to retain most of their static undrained cyclic strength, so that the resulting post-earthquake behavior is usually limited permanent deformation of the embankment, not catastrophic or flow failure. This excludes relatively loose cohesionless granular materials which are or can become saturated, and that might develop very large cyclic strains and a rapid buildup of excess pore water pressure during a strong earthquake shaking.

PRIMARY STEPS IN THE ASSESSMENT OF SEISMICALLY-INDUCED DISPLACEMENTS

The following three primary steps are involved in the applications of this simplified procedure (based on design charts), as follows:

Step I - Assessment of Yield Acceleration (K_y) of the Slope

Yield acceleration is defined as that average acceleration producing a horizontal inertial force on a potential sliding mass so as to produce a factor of safety of 1.0, and thus to cause it to experience permanent displacements. This value is a function of geometric conditions and undrained shear strength (reduced strength due to shaking or "cyclic strength") along the potential sliding mass and it is calculated using conventional limit equilibrium analyses.

Step II – Assessment of Maximum Acceleration of a Potential Sliding Mass

This step refers to evaluation of the maximum value (k_{max}) of the earthquake-induced average acceleration-time history [$k_{av}(t)$] of a potential sliding mass within earthfill slopes. This evaluation of a deformable earth structure, rather than a "rigid block" (shown on Figure F2), has been simplified by the use of design charts developed based on analyzed cases of dynamic response analyses of embankments subjected to earthquake-induced acceleration, for various potential sliding masses.

The procedure requires evaluation of peak crest acceleration, as well as an approximate distribution of peak acceleration versus depth (shown on Figures F3, F4 and F5), and an estimate of natural period of the slope being analyzed. Seed and coworkers evaluated the dynamic performance of earth structures based on both, simple close-form one-dimensional wave propagation models as well as comprehensive numerical modeling studies based on two-dimensional dynamic finite element analysis of embankments (Figure F6).

For the development of those simplified charts (Figures F7 and F9), Makdisi & Seed used:

- Strain-dependent dynamic soil parameters (shear modulus and damping ratio) which were calculated based on equivalent-linear techniques, and
- Calculated stresses acting on each element of the dynamic finite element model at each time step throughout the entire earthquake acceleration-time history (as shown in Figure F6). Normal and shear stresses along the boundary of a potential sliding mass were calculated at every time step, and their calculated resultant force, divided by the weight of the potential sliding mass to give the average acceleration acting on the sliding mass at that instant of time [$k_{av}(t)$].

The process was repeated for every time step to calculate the entire time history of the average acceleration. This acceleration is also called "effective peak acceleration" of the overall sliding mass.

Step III – Calculation of Seismically-Induced Permanent Displacements

Computation of accumulated permanent displacement along the direction of a potential sliding surface (for the initial development of these simplified design charts) was based on simple double-integration procedures (of average sliding mass acceleration-time history, where it exceeds the yield acceleration).

Based on the simplified design charts developed by Makdisi and Seed (based on previous detailed dynamic analysis for several earthfill slopes and earthquake loading conditions), accumulated permanent displacements were simply calculated based on the yield acceleration, the maximum value of acceleration of a potential sliding mass (or effective peak acceleration), and the magnitude of the earthquake for which the earthfill/landfill response is being evaluated.

PROCEDURE

The procedure involves the determination of:

Slope Geometry, Shear Wave Velocity and Natural Period

Calculation of maximum height of earthfill or refuse fill (H) at the section being considered. Section to be considered for seismic response analyses should be those resulting in the lowest static factor of safety. Evaluation would typically be made of the approximate value of shear wave velocity for the earthfill and/or refuse fill (V_s). For compacted earthfill materials, V_s is on the order of 1,000 feet per second (ft/s), and approximately 700 ft/s for refuse fill near surface, increasing with depth to approximately 900 ft/s at approximately 50 feet of depth. A simplified procedure for computing maximum crest acceleration and natural period for embankments was proposed by Makdisi and Seed (1977). The fundamental natural period of an embankment is approximated by 2.62 H/V_s.

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For the RFETS project, the anticipated maximum height and thickness of the earthfill was approximately 45 feet, which based on an estimated shear wave velocity of the refuse soil mixture of 700 feet/second, resulted in a maximum first natural period of the earthfill/landfill of approximately 0.17 seconds.

Peak Horizontal Acceleration at the Base of the Embankment/Landfill

This step requires identification of primary seismic sources (faults, area sources) which are in the proximity of the site, and determine the Richter magnitude of the maximum event that could be generated at that source, and the distance from source to the project site, and calculate peak horizontal ground acceleration using a suitable ground motion attenuation relationship. If other site geologic conditions exist, namely near surface materials consisting of soil sediments instead or rock, the peak ground surface horizontal acceleration can be estimated based on simple correlations with peak rock acceleration developed by Seed and Idriss (1982) available for various typical soil profile types of stiff soil, soft soil, deep soil.

For the RFETS project, the anticipated peak horizontal acceleration in bedrock corresponding the an earthquake event with an acceleration exceedance probability of 2 percent in 50 years, as estimated by Risk Engineering (RE, 1994) and from the 2002 USGS database, are approximately 0.10g and 0.12g (gravity), respectively.

The corresponding RFETS peak horizontal acceleration in soil (at the ground surface, at the base of the earthfill), was estimated by RE at approximately 0.15g for the same probability of exceedance. Similarly, and based on approximate correlations between peak rock acceleration and peak horizontal ground acceleration developed for a stiff soil profile (as shown on Figure F7 per Seed and Idriss, 1982), the later would be on the order of 0.12g to 0.13g, which is consistent with the RE (1995) assessment. A site-specific response spectra may also be performed using the program "shake" in place of the above two spectral relationships.

Peak Horizontal Acceleration at the Crest

The crest acceleration is approximately determined based on the spectral acceleration of the embankment/landfill. For the first mode of vibration displacement, the spectral response acceleration is approximately the peak crest acceleration of the embankment/landfill. This response should correspond to the site geologic condition, such as stiff soils, soft soils, deep soil profile, or rock, as shown on Figure F8.

Approximate spectral accelerations are available for both mean or mean plus one standard deviation (84 percentile). Seismic spectral acceleration ratios (spectral acceleration divided by the maximum ground acceleration) were developed by Seed and Idriss, 1982; Seed, Ugas, Lysmer, 1974 and 1976).

The corresponding RFETS mean spectral acceleration ratio (corresponding to the acceleration at the top of the earthfill) corresponding to a predominant natural period of 0.17 second for stiff soil condition was estimated to be approximately 2.5 to 2.6 based on Seed et al (1974, 1982). Therefore, the maximum horizontal crest acceleration would be on the order of 0.30g to 0.39g for the design earthquake event. This estimate is generally consistent with spectral acceleration by RE (1995) for 0.2 seconds of 0.39g for soil conditions (and USGS value of 0.235g for rock conditions).

Parameters Needed for Yield Acceleration Evaluations

Cyclic shear strength of a soil differs from static undrained shear strength in that, due the transient nature of earthquake loading, where seismic loads are not only variable, but might even reverse direction within a very short instant of time. Consequently, an earthfill can be subject to a number of stress pulses equal to or higher than its static failure stress, and that simply produces some permanent deformation rather than complete failure stress. Thus, for the purpose of this analysis, the **dynamic yield strength** is defined as the maximum stress level below which the material exhibits a near-elastic behavior (when subjected to cyclic stresses of number and frequencies consistent to those induced by earthquake shaking), and above which the material exhibits permanent plastic deformation (of magnitude dependent on the number and frequency of the pulses applied).

Extensive studies on the cyclic behavior of soils by special geotechnical testing in the laboratory were conduced by Seed and Chan (1966), which indicated that for conditions of no stress reversals, such as those that commonly apply to earthfill slopes, and for different values of the initial static and cyclic stress, the total stress required to produce large deformations in 10 to 100

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cycles typically ranges between 90 and 110 percent of the undrained static shear strength, as shown on Figure F6. Further, studies by Thiers and Seed (1969) indicated that undrained shear strength after cyclic loading may be expected be on the order of 90 percent of its original static shear strength as long as cyclic shear strains are less than half its static failure shear strain (also shown on Figure F6). Consequently, it may be reasonably assumed on the basis of the reported experimental data, and from the value of cyclic shear strains calculated from earthquake response analyses, that the value of cyclic yield strength for a clayey material would be between 80 to 100 percent of the static undrained strength. The later value corresponds to peak cyclic shear strain amplitudes less than one quarter of the static undrained failure strain.

Cyclic Shear Strain. From comprehensive dynamic response analyses of various earthfill dams and embankment slopes in highly seismic regions it was found that, in general, peak cyclic shear strains induced during earthquakes are expected to range from 0.1 percent for magnitude 6-1/2 earthquakes with embankment base accelerations of 0.2g (gravity) to 1 percent for magnitude 8-1/4 earthquakes with base accelerations of 0.75g (Makdisi and Seed, 1978).

In the case of the RFETS-OLF project, and considering the stiff nature of clayey materials encountered at the site, with a peak cyclic strain of less 0.1 percent, and typical static failure shear strain on the order of 3 to 5 percent, the ratio of the cyclic shear strain to the static failure strain is much less than 0.2. Consequently, reduction of the static undrained shear strength as a result of the design seismic loading is considered for all practical purposes to be insignificant. Consequently, the cyclic strength used in subsequent analyses was the same as the static undrained shear strength.

Seismic Slope Stability Analysis to Estimate Yield Acceleration. The cyclic shear strength value may be used in combination with conventional limit equilibrium analysis of slopes to compute the corresponding yield acceleration using both circular and block/wedge type potential sliding surfaces. A pseudo-static type of analysis is used to perform this calculation for several horizontal seismic coefficients. Of the several analyses conducted, the yield acceleration corresponds to the horizontal seismic coefficient resulting in a pseudo-static factor of safety of 1.0. Some interpolation is usually required.

The computed yield acceleration values for the RFETS site ranged from 0.02 to 0.04 for 18-Percent Regraded OLF site without buttress, and from 0.04 to 0.06 for 18-Percent Regraded OLF site with a buttress fill.

Ratio of Maximum Values [k_{max}] of Earthfill/Embankment Average Acceleration Time History [$k_{av}(t)$] at Various Depths [y] of a Potential Sliding Mass to Crest Acceleration [$\ddot{u}_{max}$].

Once a relationship showing variations of the maximum acceleration ration [$k_{max}/\ddot{u}_{max}$] versus depth [y] of the base of a potential sliding mass has been established for a range of earthfill and earthquake loading conditions (Figure F5), it would then be sufficient, for design purposes, to estimate the maximum crest acceleration (as described above and using Figure F8) in a given embankment due to a specified earthquake and use this relationship to determine the maximum average acceleration for any depth of the base of a potential sliding mass, as summarized in simplified design charts by Makdisi and Seed (1978).

This simplified procedure was developed by Makdisi and Seed (1978) based on the dynamic response of earthfill with heights ranging from 100 to 600 feet (Martin, 1965), natural periods of 0.25 to 5.2 seconds, which is very similar to the normalized response results published by Ambraseys and Sarma (1967) for embankments with natural periods ranging between 0.25 and 3.0 seconds in terms of average response for eight strong motion records. Another simplified procedure was proposed by Makdisi and Seed (1977) for computing maximum crest acceleration and natural period for embankments.

The shape of average results from dynamic finite element analyses is very similar to that computed based on "shear slice" method, with variations within 10 to 20 percent for the upper portion of the earthfill and 20 to 30 percent for the lower portion of the embankment. The upper bound of the proposed maximum value of the average acceleration ratio ($k_{max}/\ddot{u}_{max}$) versus depth (y) design curve may be used where a conservative estimate of accelerations is desired (rather than the average curve). For deep seated surfaces (earthfill/landfill founded on weak soils), y/H > 1 a value of 0.35 may be used.

For the RFETS project, assuming that potential slip surface could reach the base of the earthfill (or $y/H = 1$), k_{max} was found to be approximately 0.10 ± 0.02.

Earthquake-Induced Permanent Displacement Calculation

The direction of movement of the sliding mass is along the sliding surface, which is assumed to be near horizontal. This assumption is not uncommon for earthfill slopes subject to strong earthquake shaking; further, studies for other directions of the sliding surface have shown that this parameter has relatively little effect on the computed displacements. For example, it has been reported that for a sliding plane with predominantly granular materials at angles of 15 degrees from the horizontal, the computed displacements were 10 to 18 percent higher than those based on horizontal plane assumptions.

Displacements are calculated to occur every time the induced average mass acceleration exceeds the yield acceleration, by a simple numerical integration. As previously indicated, for soil types with undrained strengths not significantly affected by earthquake loading, such as in the case of the RFETS-OLF project, the yield acceleration is considered to be constant.

Simplified design charts (shown on Figure F9), which were computed by Makdisi and Seed, were used for computing earthquake-induced permanent displacement for the RFETS-OLF project, based on studies for earthfill ranging in height from 75 to 150 feet, with varying slopes, and for earthquake magnitudes of 6-1/2, 7-1/2 and 8-1/4. Because the design earthquake event recommended by RE (Risk Engineering/Geomatrix, 1995) for seismically-induced displacement analyses has a magnitude of 5.9, some extrapolation was needed, as shown on Figures F10.

Simplified Design Charts

The above-referenced study showed that ratios of yield acceleration to average acceleration of a potential sliding mass (k_y/k_{max}) at various levels between the crest and base of an earthfill slope when plotted versus computed seismically-induced permanent displacement varied similarly. Further, it was found that the computed displacements varied uniformly from a maximum value (computed from the crest average acceleration time history) to a minimum value (using the base acceleration time history), as shown on Figure F3. Therefore, maximum permanent displacements were summarized by Makdisi & Seed for these two levels.

These design curves (Figure F9) were developed for 6-1/2, 7-1/2 and 8-1/4 earthquake magnitudes and peak horizontal ground accelerations (base of the embankment) of 0.2 to 0.5g, 0.2g to 0.5g, and 0.4g to 0.75g, respectively, corresponding to earthfill slopes ranging in height from 75 to 150 feet, and having fundamental natural periods ranging from 0.6 to 1.1 seconds, 0.75 to 1.2 seconds and 0.8 to 1.5 seconds, respectively.

These simplified design charts have a range of yield acceleration ratios ky/kmax from approximately 0.05 to 0.9, and computed permanent displacements of less than one inch to several tens of feet. For example:

- For magnitude 6-1/2 earthquakes it was found that for relatively low values of yield acceleration, $k_y/k_{max} = 0.2$ for example, the range of computed permanent displacements using these simplified design charts would be on the order of 4 to 28 inches, while for higher values, such as $k_y/k_{max} = 0.5$, displacements were less than 5 inches. It should be noted that for values of $k_y/k_{max} < 0.1$, the basic assumptions of the method, namely the equivalent linear behavior and the small strain theory, become invalid. Similarly,
- For magnitude 7-1/2 earthquakes, it was found that for values of $k_y/k_{max} = 0.2$ and 0.5, the range of computed permanent displacements would be on the order of 12 to nearly 80 inches and less than 25 inches, respectively, and
- For magnitude 8-1/4 earthquakes, it was found that for values of $k_y/k_{max} = 0.2$ and 0.5, the range of computed permanent displacements would be on the order of 6 to nearly 23 feet and less than 3.5 feet, respectively.

Consequently, for the RFETS-OLF project, seismically-induced permanent displacements adjusted for magnitude M-5.9, as shown on Figure F10, are estimated to range from approximately 5 to 10 inches for the 18 percent regraded slope without buttress, and approximately 3 to 5 inches for the 18 percent regraded slope with buttress.

In general, a high static factor of safety will typically result in a relatively low permanent displacement. As the static factor of safety decreases, the calculated seismically-induced permanent displacements increase. Therefore, the static factor of safety, calculated using effective stress parameters, should be checked before performing a seismic response analysis to a get a "feel" for the overall seismic stability of the slope being analyzed.

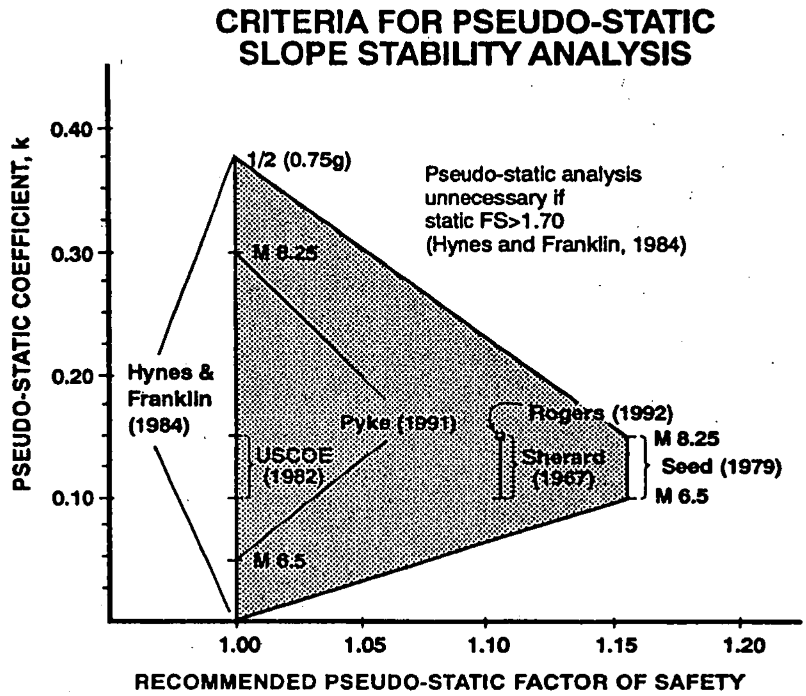

Figure 1. Approximate range of pseudo-static seismic coefficient "k" for anticipated factor of safety as proposed in the literature (references on the diagram).

Figure F1

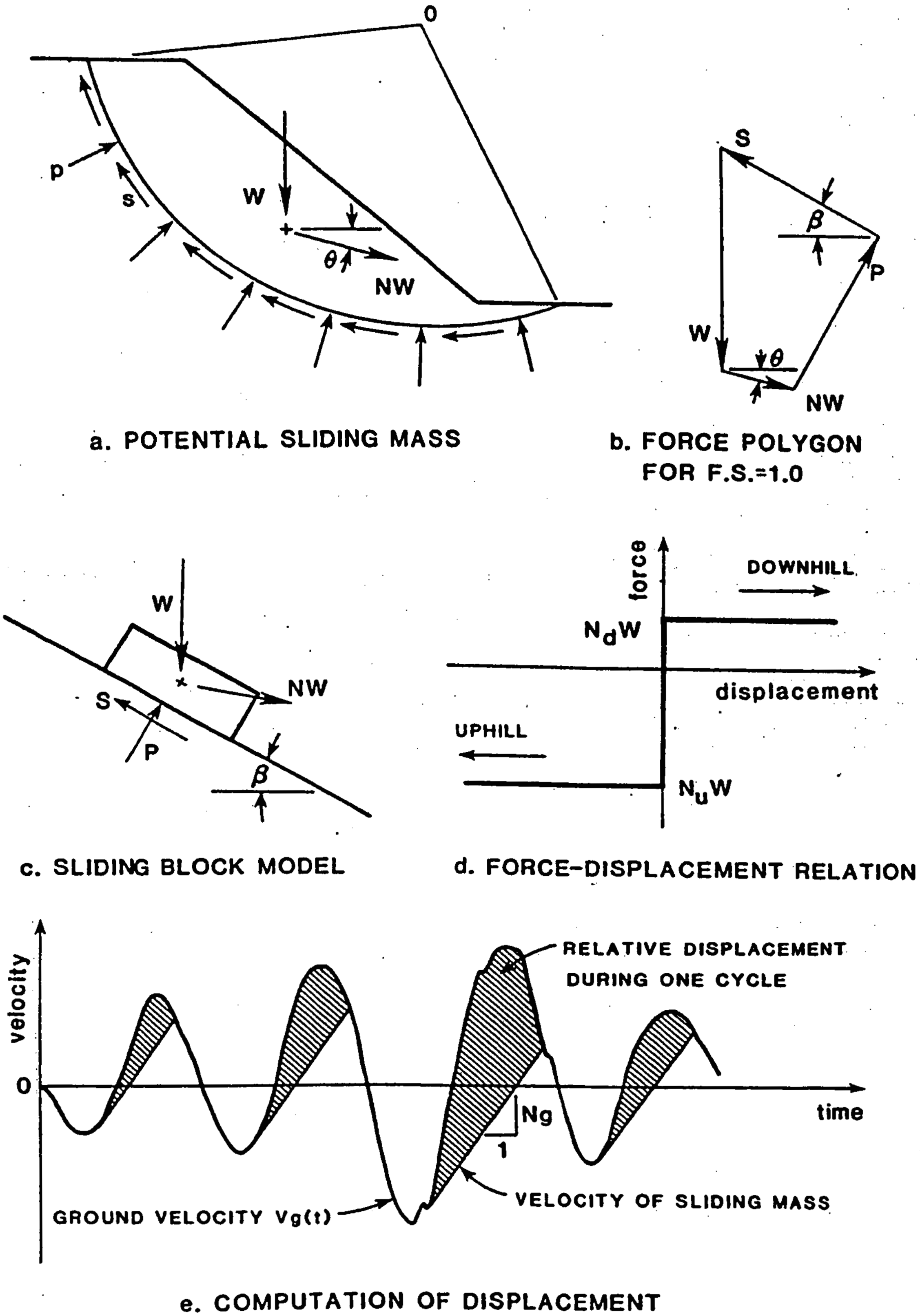

Figure 5. Elements of the sliding block analysis

Figure F2

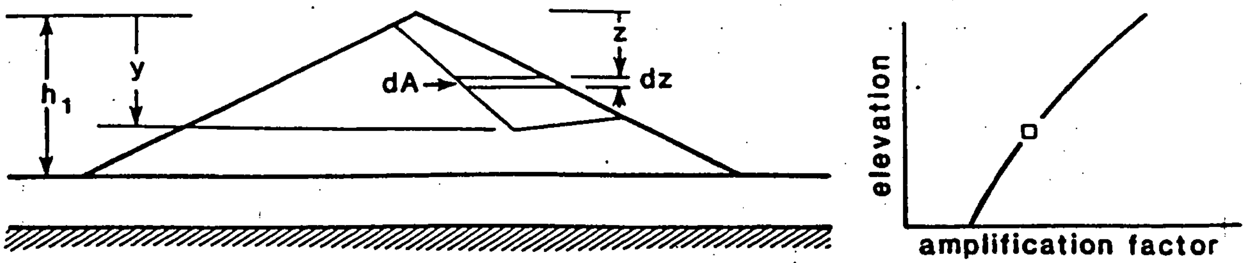

Figure 9. Computation of average acceleration acting on the sliding mass

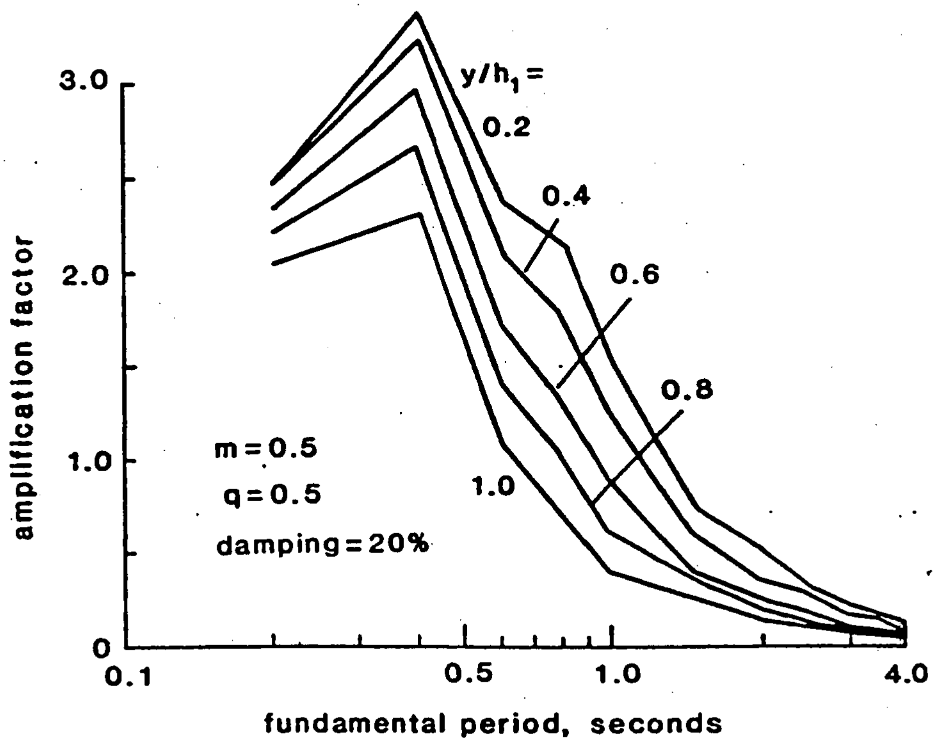

Figure 10. Amplification curves for the S 25 W component, Temblor No. 2 Record, Parkfield earthquake of 27 June 1966 (damping = 20 percent)

Figure F3

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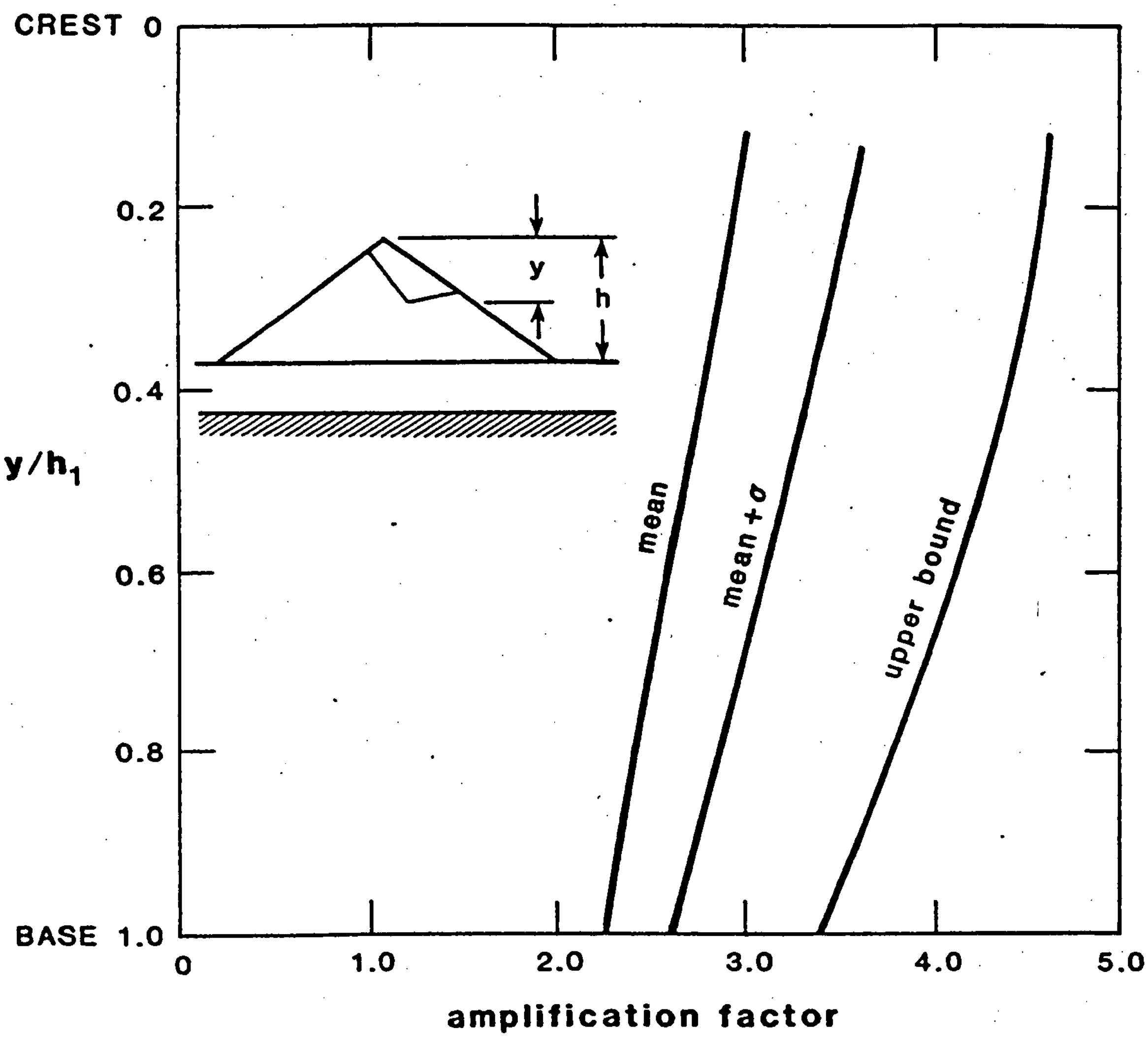

Figure 11. Amplification factors for linearly viscoelastic embankments at resonance

Figure F4

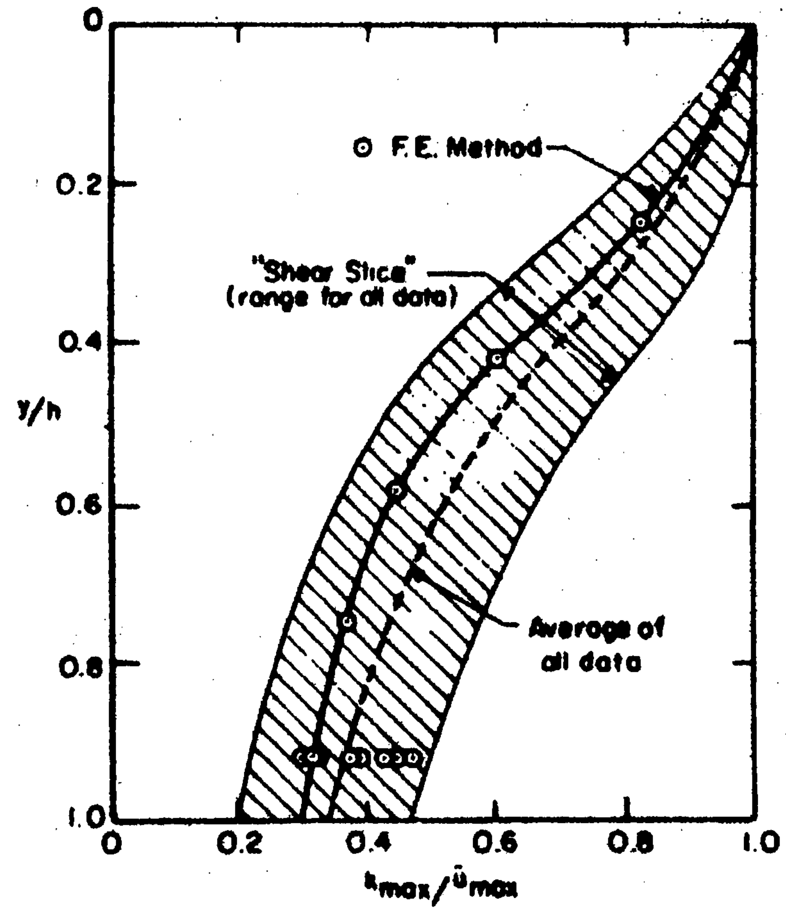

FIG. 7.—Variation of Maximum Acceleration Ratio with Depth of Sliding Mass

Figure F5

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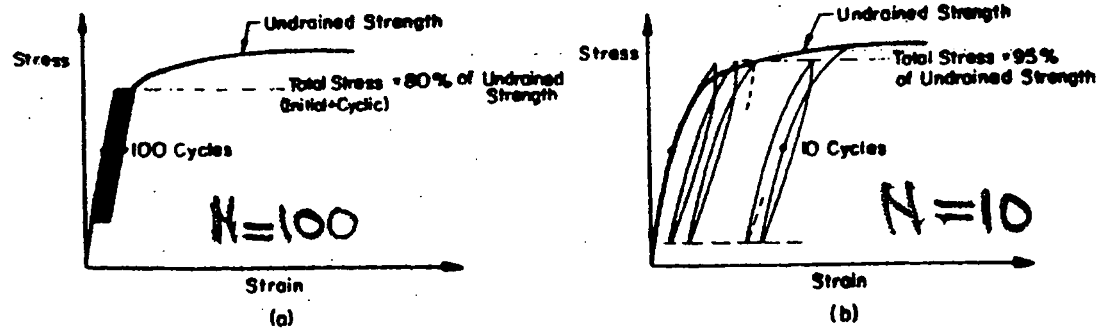


FIG. 1.—Determination of Dynamic Yield Strength

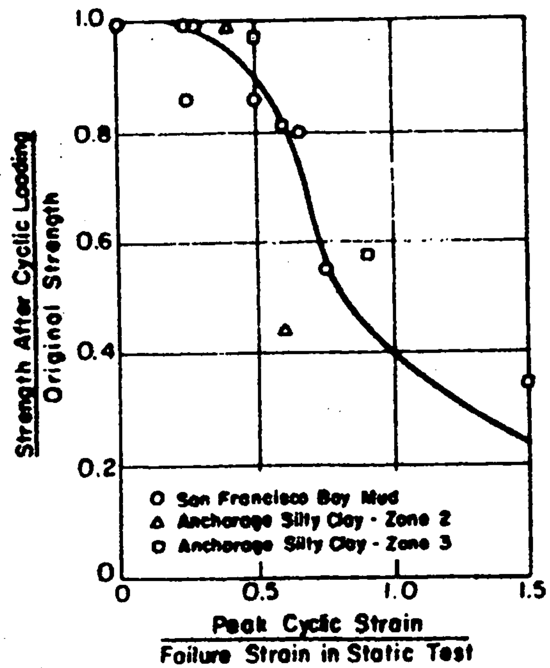
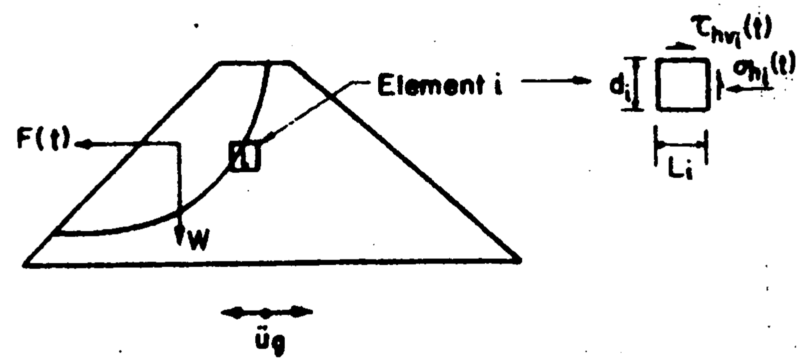


FIG. 2.—Reduction in Static Undrained Strength Due to Cyclic Loading (29)

Figure F6



$$F(t) = \sum_{i=1}^{n} \tau_{hv_i}(t)\,L_i + \sigma_{h_i}(t)\,d_i$$

n = number of elements along the sliding surface

$$k_{av}(t) = F(t)/W$$

FIG. 3.—Calculation of Average Acceleration from Finite Element Response Analysis

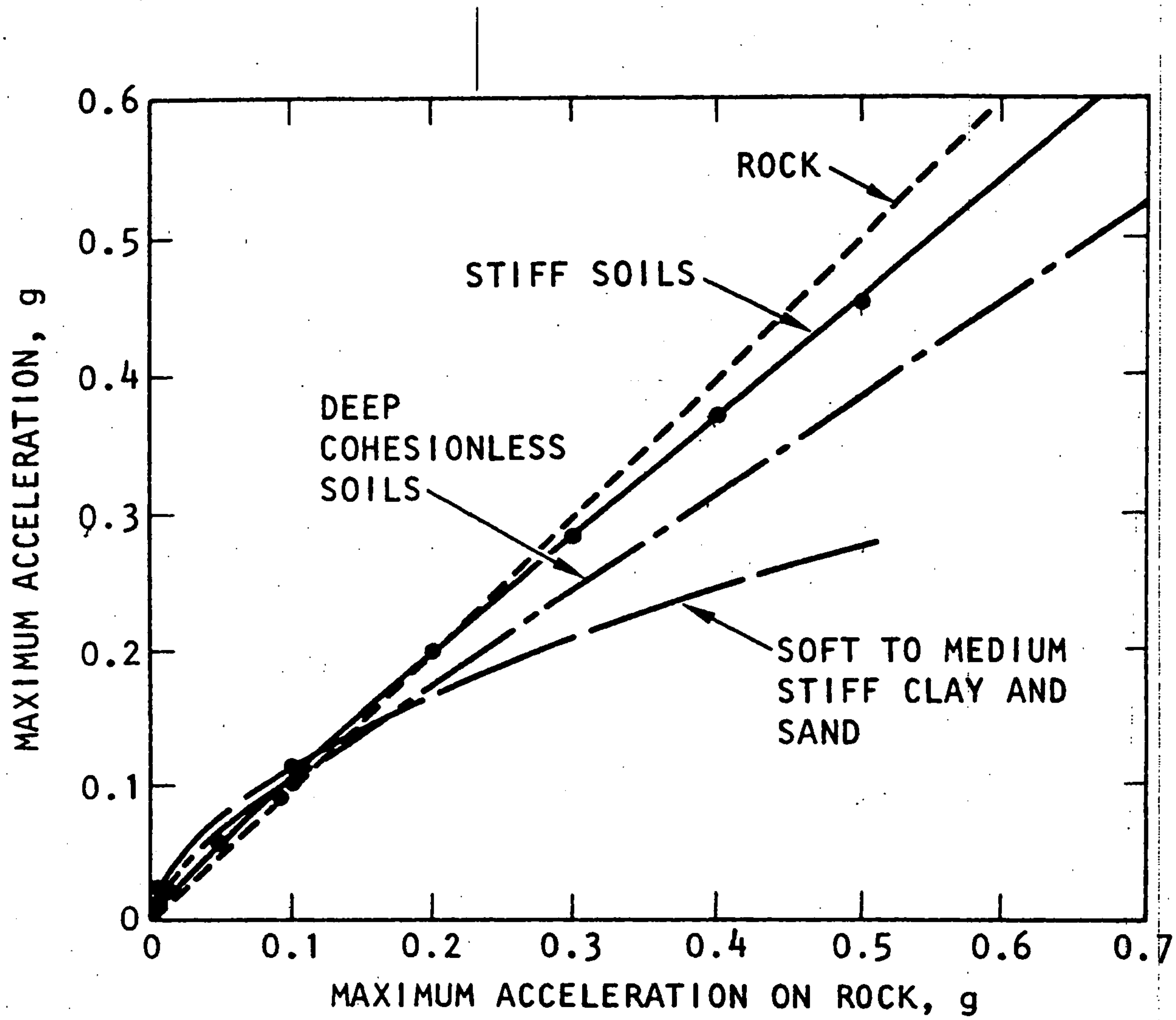


Figure 19. Approximate relationships between maximum accelerations on rock and other local site conditions.

Figure F7

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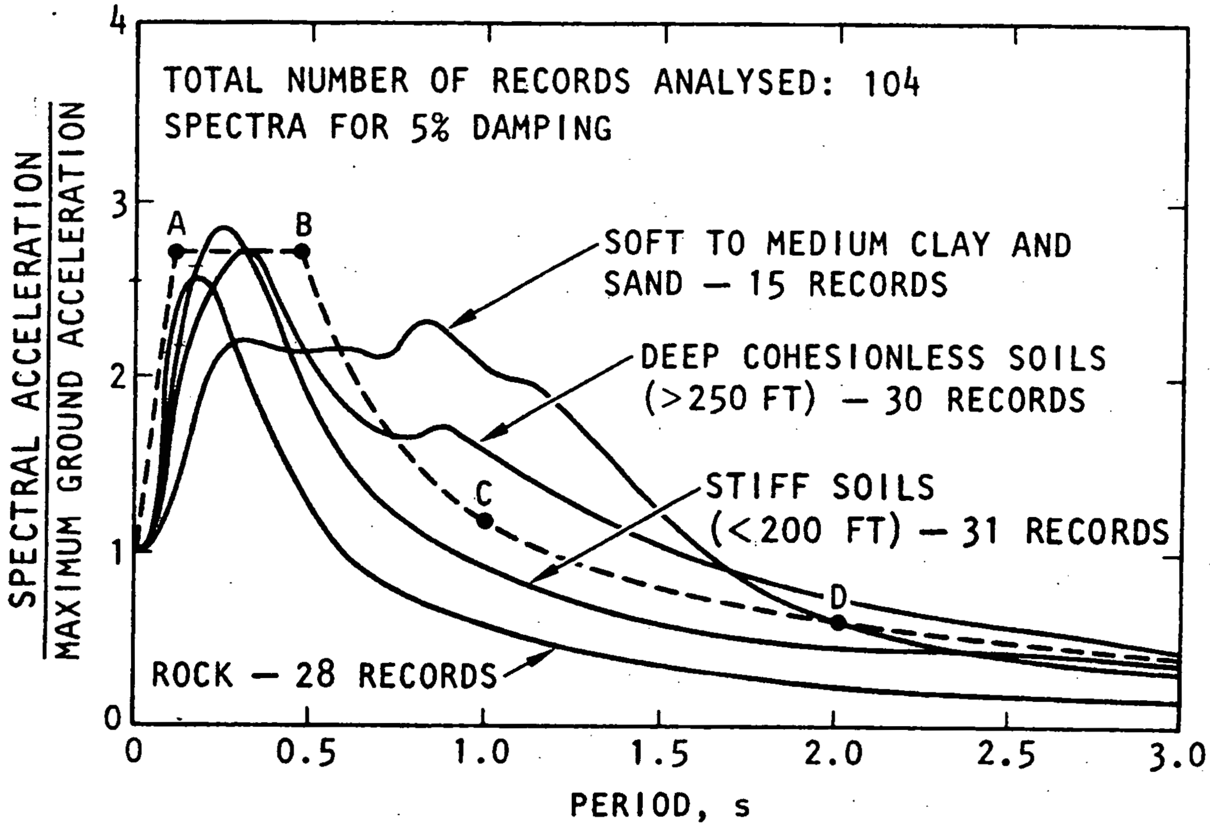
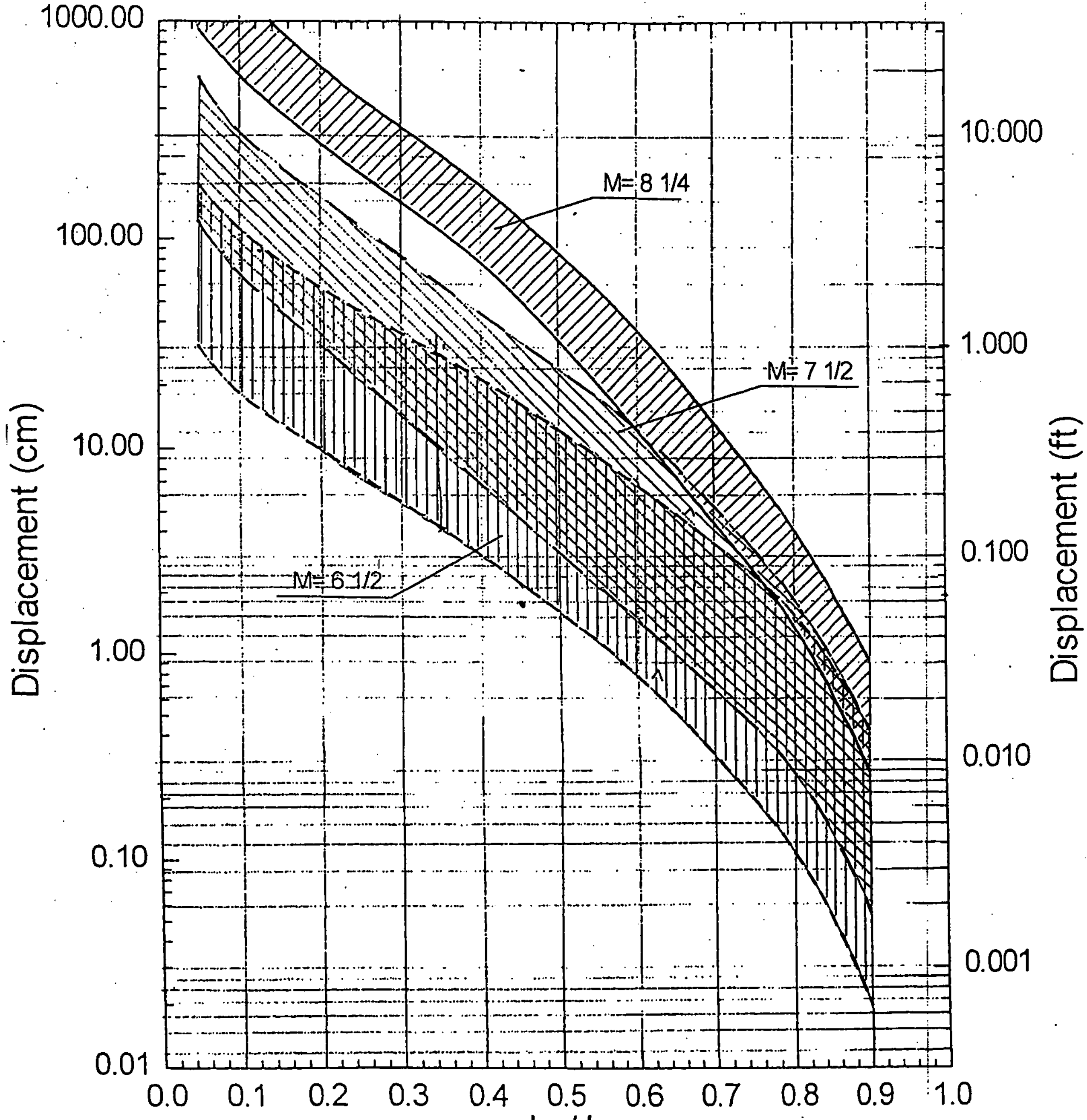


Figure 24. Average acceleration spectra for different site conditions.

Figure F8



After Makdisi & Seed (1978)

Figure F9

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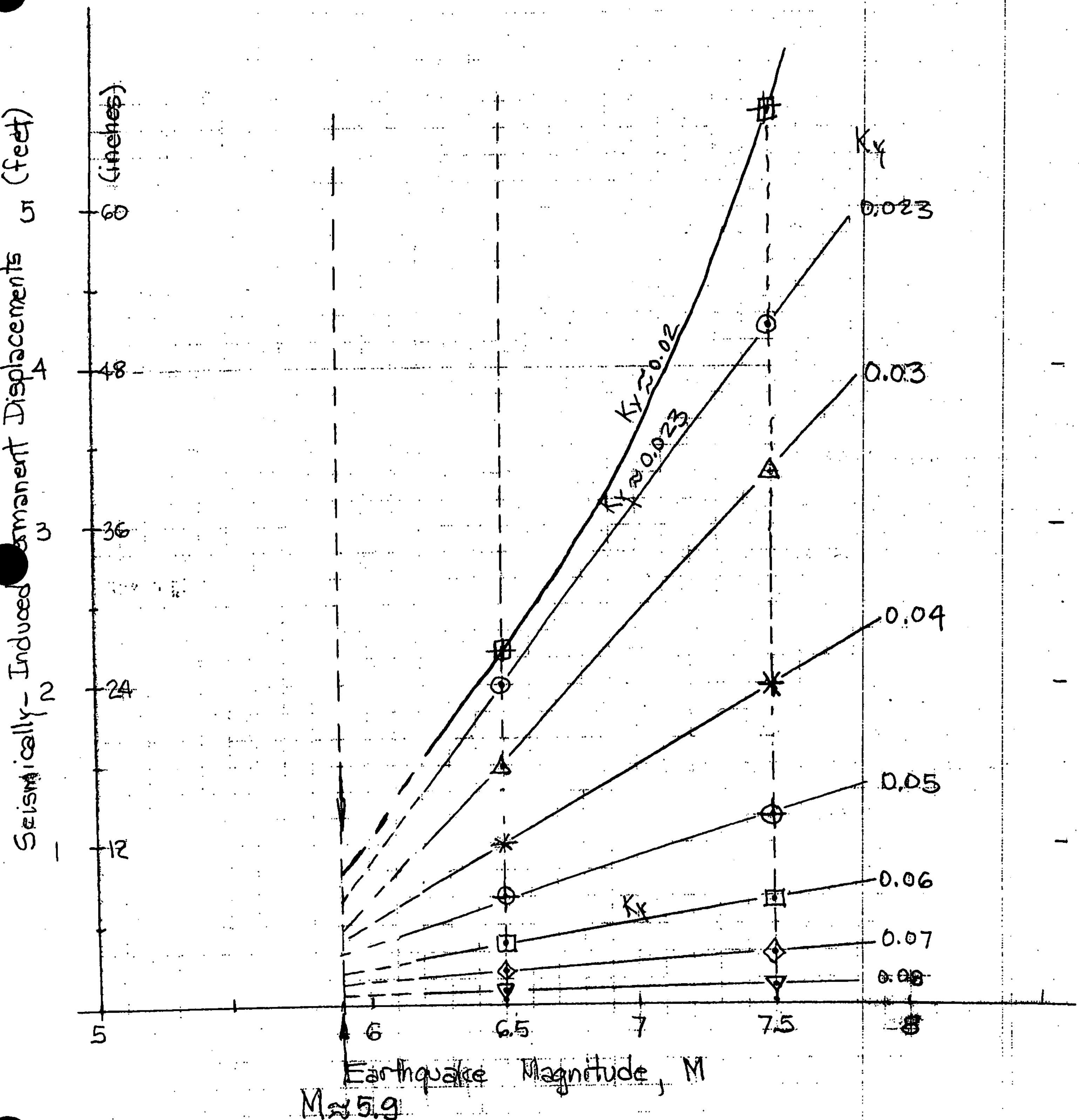

Seismically-Induced Permanent Displacements (feet) (inches)
5
60
4
48
3
36
2
24
1
12
5
6
6.5
7
7.5
8
Earthquake Magnitude, M
M≈5.9
Ky
0.023
0.03
0.04
0.05
0.06
0.07
0.08
Ky≈0.02
Ky≈0.023
Ky

Figure F10

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DRAFT INTERIM MEASURE/INTERIM REMEDIAL ACTION FOR THE ORIGINAL LANDFILL (INCLUDING IHSS GROUP SW-2; IHSS 115, ORIGINAL LANDFILL AND IHSS 196, FILTER BACKWASH POND)

Environmental Restoration

Rocky Flats Environmental Technology Site

December 6, 2004

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DRAFT INTERIM MEASURE/INTERIM REMEDIAL ACTION FOR THE ORIGINAL LANDFILL (INCLUDING IHSS GROUP SW-2; IHSS 115, ORIGINAL LANDFILL AND IHSS 196, FILTER BACKWASH POND)

December 6, 2004

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ACRONYMS AND ABBREVIATIONS

AAESE	Accelerated Action Ecological Screening Evaluation
AHA	Activity Hazard Analysis
AL	action level
ALF	Action Levels and Standards Framework for Surface Water, Ground Water, and Soil
Am	americium
AOC	Area of Concern
APEN	Air Pollutant Emission Notice
AR	Administrative Record
AR	Administrative Record
ARAR	applicable or relevant and appropriate requirement
bgs	below ground surface
BMP	best management practice
BZ	Buffer Zone
CAD/ROD	Corrective Action Decision/Record of Decision
CAQCC	Colorado Air Quality Control Commission
CCR	Code Colorado of Regulations
CDPHE	Colorado Department of Public Health and Environment
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CFR	Code of Federal Regulations
cfs	cubic feet per second
CHWA	Colorado Hazardous Waste Act
CID	Cumulative Impacts Document
CMS/FS	Corrective Measures Study/Feasibility Study
COC	contaminant of concern
CRA	Comprehensive Risk Assessment
cy	cubic yard

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ACRONYMS AND ABBREVIATIONS

DOE	U.S. Department of Energy
DOI	U.S. Department of Interior
DQO	data quality objective
ECOC	ecological contaminant of concern
EPA	U.S. Environmental Protection Agency
ERA	Ecological Risk Assessment
EU	exposure unit
FIDLER	Field Instrument for the Detection of Low-Energy Radiation
FY	fiscal year
GIS	Geographic Information System
HAP	hazardous pollutant
HASP	Health and Safety Plan
HPGe	high-purity germanium
HRR	Historical Release Report
IA	Industrial Area
IABZSAP	Industrial Area Buffer Zone Sampling and Analysis Plan
ICP/MS	inductively coupled plasma mass spectrometry
IDL	instrument detection limit
IGD	Implementation Guidance Document
IHSS	Individual Hazardous Substance Site
IM/IRA	Interim Measure/Interim Remedial Action
IMP	Integrated Monitoring Plan
ISMS	Integrated Safety Management System
IWCP	Integrated Work Control Program
kg	kilogram
K-H	Kaiser-Hill Company, L.L.C.
LDR	Land Disposal Restriction
LHSU	lower hydrostratigraphic unit

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ACRONYMS AND ABBREVIATIONS

LRA	Lead Regulatory Agency
MDL	method detection limit
µg/kg	micrograms per kilogram
µg/L	micrograms per liter
mg/kg	milligrams per kilogram
mg/L	milligrams per liter
MOU	Memorandum of Understanding
NAAQS	National Ambient Air Quality Standard
nCi/g	nanocuries per gram
NCP	National Oil and Hazardous Substances Pollution Contingency Plan
NEPA	National Environmental Policy Act
NESHAP	National Emission Standard for Hazardous Air Pollutants
NFAA	No Further Accelerated Action
NOI	Notification of Intent
NPDES	National Pollutant Discharge Elimination System
NPL	National Priority List
O+M	operation and maintenance
OLF	Original Landfill
OSHA	Occupational Safety and Health Administration
OU	Operable Unit
PAC	Potential Area of Concern
PAH	polynuclear aromatic hydrocarbon
PCB	polychlorinated biphenyl
PCE	tetrachloroethene (or perchloroethene)
pCi/L	picocuries per liter
PCOC	potential contaminant of concern
PMJM	Preble's meadow jumping mouse
POC	Point of Compliance

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ACRONYMS AND ABBREVIATIONS

PPE	personal protective equipment
psf	pounds per square foot
Pu	plutonium
QA	quality assurance
RAO	remedial action objective
RCRA	Resource Conservation and Recovery Act
RFCA	Rocky Flats Cleanup Agreement
RFETS or Site	Rocky Flats Environmental Technology Site
RFI/RI	RCRA Facility Investigation/Remedial Investigation
RI/FS	Remedial Investigation/Feasibility Study
RL	reporting limit
SID	South Interceptor Ditch
Sr	strontium
SVOC	semivolatile organic compound
SWD	Soil Water Database
SWWB	Site-Wide Water Balance
TCE	trichloroethene
TCLP	Toxicity Characteristic Leaching Procedure
TSP	total suspended particulates
U	uranium
USFWS	U.S. Fish and Wildlife Service
USHU	upper hydrostratigraphic unit
VOC	volatile organic compound
WQP	water quality parameter
WRW	wildlife refuge worker
WY	Water Year

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EXECUTIVE SUMMARY

This Interim Measure/Interim Remedial Action (IM/IRA) Decision Document presents the proposed accelerated action to remediate Individual Hazardous Substance Site (IHSS) Group SW-2 at the Rocky Flats Environmental Technology Site (RFETS or Site). IHSS Group SW-2 consists of two IHSSs: IHSS 115, the Original Landfill (OLF), and IHSS 196, the Filter Backwash Pond.

The OLF is a 20-acre area where construction debris and general facility wastes were placed from 1950 to 1968. The OLF is located on a south-facing slope just south of the Industrial Area (IA) pediment and borders the northern side of Woman Creek.

This IM/IRA summarizes the environmental data for IHSS Group SW-2, compares the data to Rocky Flats Cleanup Agreement (RFCA) action levels (ALs), presents and evaluates accelerated action alternatives, and describes the proposed action. Recent geotechnical data and groundwater modeling at the OLF are also summarized in the IM/IRA.

A review of the environmental data concludes the following:

- **Surface Soils**: Metals, radionuclides, and organic compounds have been detected above background levels in surface soil; however, only uranium and a few polynuclear aromatic hydrocarbons (PAHs) are present in surface soil above the RFCA ALs. Uranium contamination is present in surface soil above the ALs at four sample locations. PAHs are ubiquitous in surface soil at the OLF; however, only two sample locations have PAH concentrations that exceed the ALs,

- **Subsurface Soils**: Metals, radionuclides, and organics have been detected above background levels in subsurface soil; however, only PAHs were detected above the ALs and only in an isolated location.

- **Groundwater**: Metals, radionuclides, and organic compounds have been detected in groundwater at concentrations that are above background and the Tier II ALs. However, the number of detections above background and the Tier II ALs was generally very low for all of these constituents, and their concentrations were also generally very low relative to background and the Tier II ALs. There are no Tier I exceedances for any constituents. Furthermore, chlorinated solvent contamination in groundwater does not extend downgradient of the OLF. The most recent volatile organic compound (VOC) data for these wells (last 3 years) indicate that chlorinated solvents are either not detected, or detected at trace concentrations below 1 µg/L. There is no plume of contaminated groundwater emanating from the OLF. Groundwater fate and transport modeling also indicates that the constituents in groundwater will not reach Woman Creek above detectable levels. Therefore, groundwater quality is not significantly impacted by the OLF.

- **Surface Water**: Several metals, radionuclides, and organic compounds have been detected above background levels within Woman Creek surface water downgradient of

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the OLF. However, the concentrations of many of these analytes were only occasionally above the surface water ALs (approximately 5 percent or fewer of the observations), and were generally low in magnitude relative to the surface water ALs. Several metals and organics detected above background in surface water downgradient of the OLF have not been detected above background in upgradient surface water. However, these analyte concentrations typically were low relative to the surface water ALs, with only infrequent concentrations above the surface water ALs (fewer than 7 percent of any analyte sampled exceeded the AL). This frequency of occurrence is not sufficient to indicate that the OLF has had a significant impact on surface water quality.

- **Sediments**: A few metals were detected above background in the sediment of Woman Creek and the South Interceptor Ditch (SID) in the vicinity of the OLF; however, concentrations were orders of magnitude below the RFCA ALs.

During the 1995 geotechnical study, historic areas of discrete landslides were identified in the area of the OLF before any waste was placed. However, there are no indications of landsliding at the OLF since waste disposal stopped in 1968. Erosion and sloughing of the hummocky surface due to historic waste placement and faulty stormwater management practices have exposed some waste at the surface of the OLF. Geotechnical testing (conducted in 2004) has provided data to further evaluate the structural stability of the OLF. These data have provided additional information on the strength of the underlying subsoil and weathered bedrock to be used in the design of the accelerated action.

Four accelerated action alternatives have been evaluated in the IM/IRA to address direct contact with the waste materials, control stormwater and erosion, and address the structural stability of the OLF. These four accelerated action alternatives include:

- No Action
- Removal of surface soil "hot spots" and site grading with a soil cover;
- Removal of surface soil "hot spots," and site grading with a soil cover and buttress fill at the toe of the OLF slope (this alternative also includes an evaluation of an upgradient groundwater "cutoff" wall); and
- Removal of surface soil "hot spots," and removal and off-site disposal of the wastes placed at the OLF.

A comparative evaluation has been conducted on these accelerated action alternatives using the criteria of effectiveness, implementability, structural stability, and relative cost. Site grading with a soil cover is the proposed accelerated action for the OLF for the following reasons:

- The surface soil areas with concentrations that exceeded the uranium ALs were removed in August 2004.
- Regrading the site will eliminate the ponding of stormwater at the surface of the OLF and provide for positive runoff and run-on control of stormwater.

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- Adding a soil cover will eliminate the exposure and direct contact of the waste materials at the surface of the OLF.

- Reducing the existing surface slopes (regrading) will eliminate surface soil sloughing and erosion, and provide a structurally stable area to contain the waste materials.

- Implementing this proposed accelerated action would not permanently impact the habitat of the Preble's Meadows Jumping Mouse or impact Woman Creek.

- Implementing this proposed accelerated action is cost effective since the data and OLF evaluations indicate the OLF is not now a significant source of contamination to the environment

Actions undertaken to implement the approved accelerated action will be documented in a Closeout Report.

Post-accelerated action monitoring and maintenance are also described in the IM/IRA and include, groundwater monitoring, surface water monitoring, and monitoring of the structural stability of the graded slope.

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1.0 INTRODUCTION

This Interim Measure/Interim Remedial Action (IM/IRA) Decision Document presents the proposed accelerated action to remediate Individual Hazardous Substance Site (IHSS) Group SW-2 at the Rocky Flats Environmental Technology Site (RFETS or Site). IHSS Group SW-2 consists of two IHSSs: IHSS 115, the Original Landfill (OLF), and IHSS 196, the Filter Backwash Pond.

RFETS is a Comprehensive Environmental Response, Compensation and Liability Act (CERCLA) National Priority List (NPL) site and is located in rural northern Jefferson County, Colorado, approximately 16 miles northwest of Denver. It is approximately 6,265 acres in area. The developed portion of the Site, referred to as the IA, is centrally located within RFETS and occupies approximately 365 acres. The Rocky Flats Buffer Zone (BZ) surrounds the IA and occupies the remaining 5,900 acres. IHSS Group SW-2 is located in the southern part of the IA Operable Unit (OU) and adjacent to the Buffer Zone OU. Figures 1-1 and 1-2 present the locations of the Site and IHSSs 115 and 196, respectively.

The Rocky Flats Cleanup Agreement (RFCA) (DOE et al. 1996) is a CERCLA federal facility cleanup agreement as well as a compliance order on consent under the Resource Conservation and Recovery Act (RCRA) and the Colorado Hazardous Waste Act (CHWA) between the U.S. Department of Energy (DOE), the U.S. Environmental Protection Agency, Region VIII (EPA), and the Colorado Department of Public Health and Environment (CDPHE). RFCA provides the regulatory framework for cleanup of hazardous substances at the Site. In accordance with RFCA, this IM/IRA is subject to CDPHE, EPA, and public review and comment, and also approval by CDPHE, the Lead Regulatory Agency for RFCA accelerated actions in the IA OU.

This IM/IRA presents the environmental data for IHSS Group SW-2, compares the data to RFCA action levels (ALs), presents and evaluates accelerated action alternatives, and describes the proposed actions. Actions undertaken to implement the approved accelerated action will be documented in a Closeout Report.

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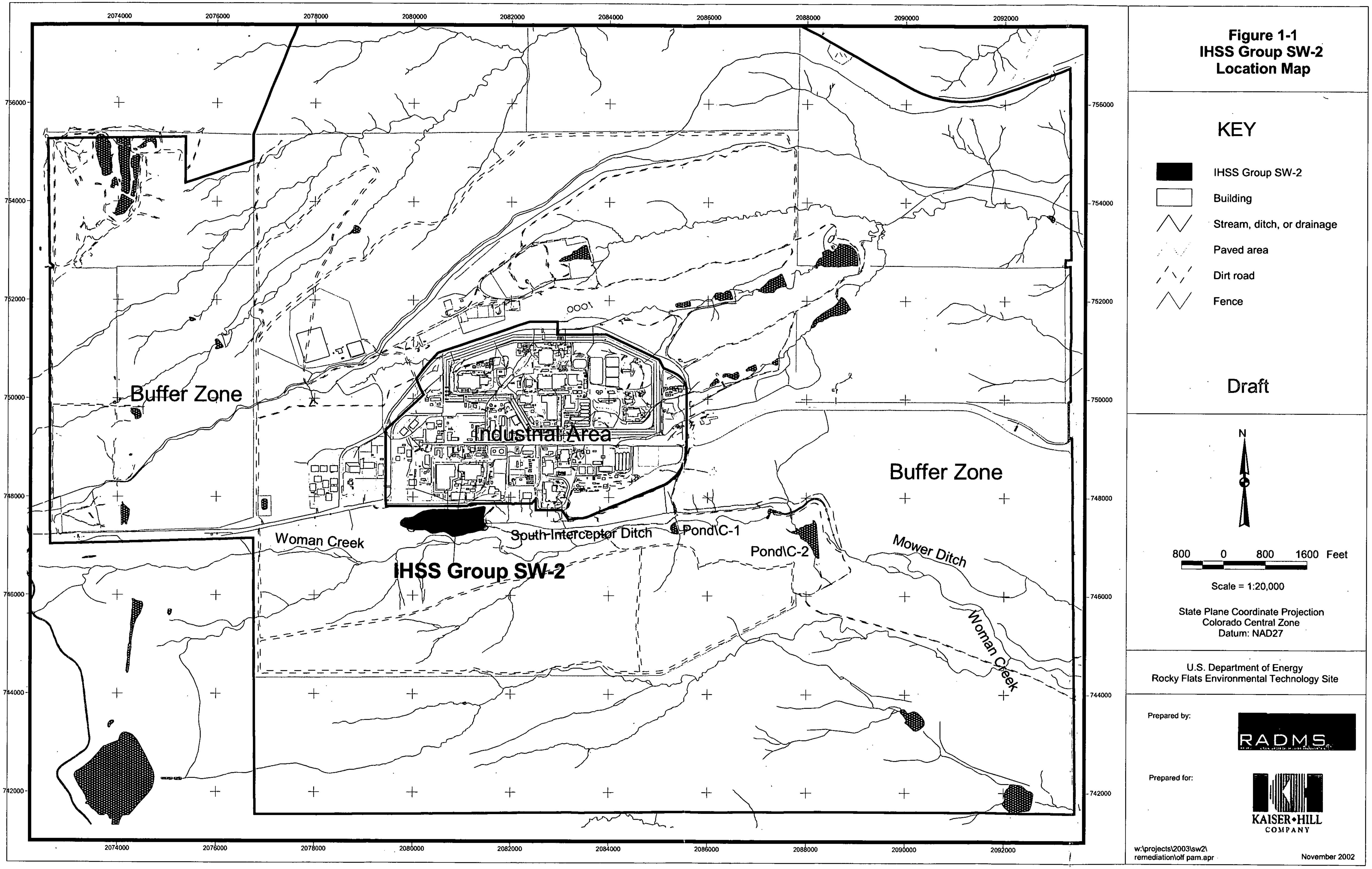
Buffer Zone
Industrial Area
Buffer Zone
Woman Creek
South Interceptor Ditch
Pond\C-1
Pond\C-2
Mower Ditch
Woman Creek
IHSS Group SW-2
Figure 1-1
IHSS Group SW-2
Location Map
KEY
IHSS Group SW-2
Building
Stream, ditch, or drainage
Paved area
Dirt road
Fence
Draft
N
800 0 800 1600 Feet
Scale = 1:20,000
State Plane Coordinate Projection
Colorado Central Zone
Datum: NAD27
U.S. Department of Energy
Rocky Flats Environmental Technology Site
Prepared by:
RADMS
Prepared for:
KAISER•HILL COMPANY
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November 2002

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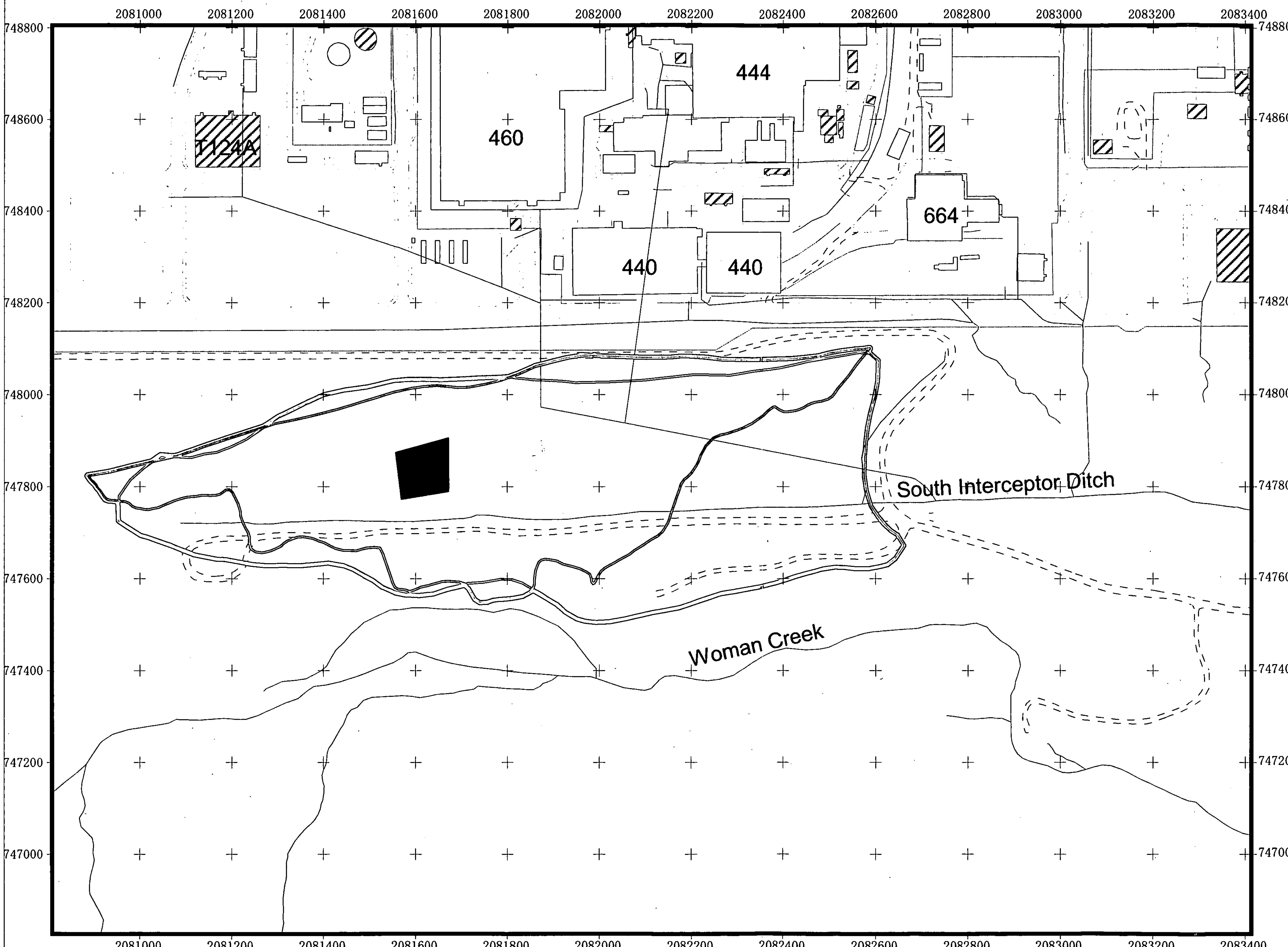

Figure 1-2
Location of IHSS 115 and IHSS 196

KEY

- Waste material boundary
- IHSS SW-115
- Original Landfill Area of Concern
- IHSS SW-196
- Standing building
- Demolished building
- Streams
- Paved area
- Dirt road
- Fence

DRAFT

N

70 0 70 140 210 Feet

Scale = 1:2,500

State Plane Coordinate Projection
Colorado Central Zone
Datum: NAD 27

U.S. Department of Energy
Rocky Flats Environmental Site

Prepared by:
RADMS

Prepared for:
KAISER•HILL COMPANY

File: w:\projects\2003\sw-2\remediation\olf pam.apr

Date: 01/07/04

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1.1 Need for RFCA Accelerated Action

Between 1952 and 1968, approximately 74,000 cubic yards of solid waste consisting of construction and other debris and general plant waste contaminated with or commingled with small amounts of wastes with hazardous constituents were disposed in the approximately 20-acre OLF, IHSS-115. The OLF is located on the southern-facing slope just south of the IA pediment and borders the northern side of Woman Creek. Because of the slope angle and underlying bedrock characteristics, this area has been identified as susceptible to landslides and erosion.

From the early 1950s until 1971, filter backwash wastewater generated by the raw water treatment process in Building 124 to make potable water was discharged to settling and evaporation ponds located roughly in the center of IHSS 115, designated the Filter Backwash Pond, IHSS 196. A soil cover was placed over the disposed waste when the OLF was closed in 1968. Some of the wastes and debris have become exposed through erosion of the soil cover over the wastes that were placed at steep slopes. Besides the soil cover, soil fill material was used in the waste disposal operation. The volume of disposed waste and commingled soil is estimated at 160,000 cubic yards.

IHSSs 115 and 196 were formerly part of OU 5, the Woman Creek Priority Drainage, which was consolidated into the IA OU when RFCA became effective in July 1996. Prior to this consolidation, a Phase 1 RCRA Facility Investigation/Remedial Investigation (RFI/RI) for OU-5 was conducted pursuant to an RFI/RI Work Plan, which was approved by CDPHE and EPA in 1992 (EPA 1992a, 1992b; CDPHE 1992). For purposes of the investigation work the OU-5 IHSSs (and Potential Areas of Concern [PACs]) were separated into specific Areas of Concern (AOCs). The IHSSs 115 and 196 were designated AOC 1.

One of the purposes of the OU-5 Phase 1 RFI/RI for the OLF was to gather sufficient geotechnical information to evaluate landslide mechanisms in the OLF. The OU-5 Phase 1 RFI/RI also included source and environmental media characterization for the OLF and a human health and ecological risk assessment for Area 1. The OU-5 Phase 1 RFI/RI Report was completed in 1996 (Kaiser-Hill 1996).

Section 2.0, Site Background, Section 3.0, Environmental Setting, and Section 4.0, Environmental Data Summary and RFCA Action Level Comparison of this IM/IRA, provide detailed information about the OLF and Filter Backwash Pond history and the OU-5 Phase 1 RFI/RI.

In addition to the problems posed by inadequate soil cover, which allows possible direct contact with the disposed wastes, sampling and analysis of soil, surface water, and groundwater have shown some contamination above background levels. Some organic compounds and metals (including depleted uranium) contamination is present at levels greater than action levels and/or standards applicable to these media contained in the *Action Levels and Standards Framework for Surface Water, Ground Water and Soils* (ALF), RFCA Attachment 5. Pursuant to RFCA, if ALF action levels or standards are exceeded, an evaluation, remedial action, and/or management action is triggered.

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DOE proposes to conduct a remedial action for the OLF and Filter Backwash Pond. Pursuant to RFCA, remedial actions taken for one or more IHSSs will be conducted as a RFCA accelerated action. Because this accelerated action is estimated to take longer than six months from the time of commencement of physical work to complete, RFCA requires that the work will be conducted pursuant to an IM/IRA. Section 11.0, Implementation Schedule of this IM/IRA, provides an informational schedule for the major work activities, which are expected to take just over 6 months to complete.

1.2 Proposed Accelerated Action – The Municipal Landfill Presumptive Remedy

EPA has published two directives regarding the application of the "source containment" presumptive remedy to municipal and military landfills (EPA 1993a, 1996).

> *"Presumptive remedies are preferred technologies for common categories of sites based on historical patterns of remedy selection and EPA's scientific and engineering evaluation of performance data on technology implementation. By streamlining site investigation and accelerating the remedy selection process, presumptive remedies are expected to ensure consistent selection of remedial actions to reduce the cost and time required to clean up similar sites. Presumptive remedies are expected to be used at all appropriate sites. Site-specific circumstances dictate whether a presumptive remedy is appropriate at a given site."*

Application of the CERCLA Municipal Landfill Presumptive Remedy to Military Landfills, OSWER Directive No. 9355.0-67FS, December 1996, p.1. The directive recognizes that military landfills may contain waste types that are different from those found in municipal landfills but that pose a hazard profile similar to that of municipal landfills. The directive provides criteria for evaluating whether the landfill contents have characteristics similar to municipal landfill contents. If the characteristics are similar, then the presumptive remedy should be considered and implemented if appropriate. Although, the OLF is not on a military base, because of its size and waste types, it is similar to military landfills at other NPL Sites where the presumptive remedy has been implemented.

EPA has also published several directives regarding conducting and streamlining Remedial Investigations/Feasibility Studies at CERCLA municipal landfill sites (EPA 1991a; 1994). The presumptive remedy process involves using existing data to the extent possible and limiting the characterization of the landfill contents, conducting a streamlined risk assessment, and developing a focused feasibility study to analyze only those alternatives consisting of appropriate components of the presumptive remedy.

The OU-5 Phase 1 RFI/RI Report and groundwater and surface water monitoring provide sufficient information to evaluate the OLF in accordance with the military and municipal landfill presumptive remedy guidance. Section 5.0, Remedial Objectives of this IM/IRA, provides a discussion of whether the "source containment" remedy is appropriate. Section 6.0, Remedial Action Alternatives Evaluation, and Section 7.0, Proposed Remedial

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Action Plan, provide details regarding the components of the proposed source containment remedy. Section 6.0 also evaluates the "no action" and removal alternatives.

Section 8.0, Applicable or Relevant and Appropriate Requirements (ARARs), along with Appendix A, provides a discussion of the regulations pertaining to this accelerated action. Section 9.0, Environmental Impacts, presents an analysis of the environmental consequences associated with the proposed action. Section 10.0, Additional Long-Term Stewardship Considerations, identifies additional post-accelerated action activities to be implemented.

Section 13.0, Administrative Record, identifies the documents considered by DOE, CDPHE, and EPA in proposing this accelerated action, which are available for public review at the Rocky Flats Reading Room.

2.0 SITE BACKGROUND

2.1 IHSS Group SW-2 Site Description

IHSS Group SW-2 covers approximately 20 acres and includes two IHSSs: IHSS 115, the OLF, and IHSS 196, the Filter Backwash Pond. IHSS 115 is located south of the RFETS IA pediment on a south-facing hill slope north of Woman Creek. IHSS 196 lies approximately in the center of IHSS 115. Approximately 1,000 ft of the South Interceptor Ditch (SID), and storm drain and building footer drain discharge pipes and other disturbed areas lie within IHSS 115. (See Figure 2-1). These IHSSs were formerly part of OU 5, Woman Creek Priority Drainage. An OU 5 Phase I RFI/RI was conducted in accordance with an approved work plan; a final report was issued in April 1996 (Kaiser-Hill 1996).

2.2 Description and History of IHSS 115 (OLF)

The OLF was used to dispose of solid sanitary and construction debris wastes generated at the Rocky Flats Plant from 1952 to 1968 (Rockwell 1988). The landfill was not designed or operated as an engineered landfill. Aerial photographs indicate that the landfill was operated as an area fill (EG&G 1994). Waste was merely dumped in the area vertically below and just south of the southern edge of the alluvial pediment on which the RFETS IA is located. The waste disposal area lies north of Woman Creek. The waste was generally spread over the south-facing hillside, serving to fill in the area below the pediment edge. No liner or other collection barrier was installed between the waste and the existing surfaces.

In the waste placement process, the waste material was mixed with soil materials. The volume of disposed waste and commingled soil is estimated at 160,000 cubic yards. Because of the slope angle, and the geological mapping and characterization of the colluvial and weathered bedrock material making up the hillside, the hillside in this area has been identified as susceptible to sliding even before the slope was covered with waste fill (Metcalf & Eddy 1995).

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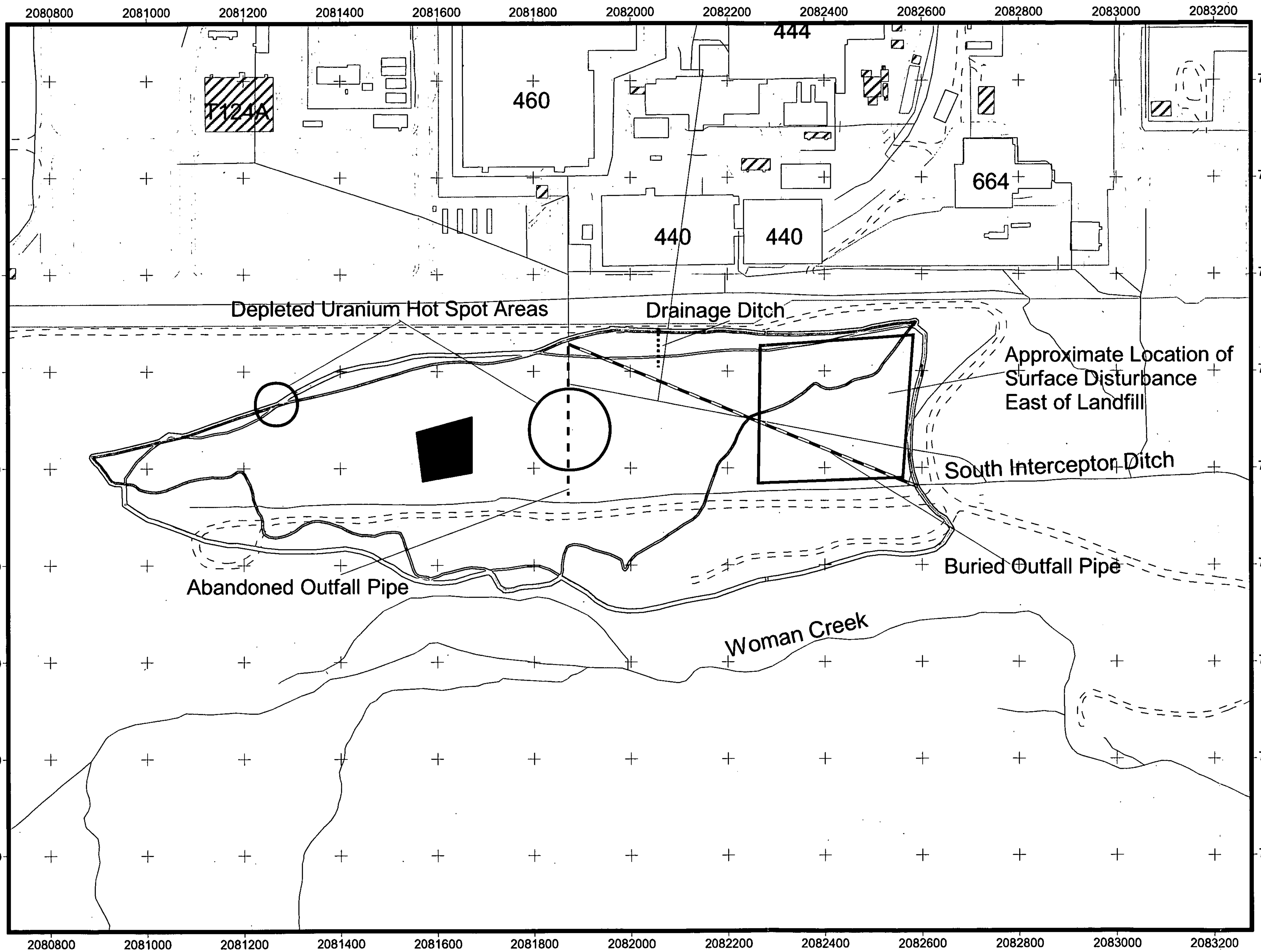

Figure 2-1
Original Landfill Features

KEY

- Waste material boundary
- IHSS SW-115
- Original Landfill Area of Concern
- IHSS SW-196
- Standing building
- Demolished building
- Streams
- Paved area
- Dirt road
- Fence

DRAFT

N W E S

100 0 100 200 300 Feet

Scale = 1:2,500

State Plane Coordinate Projection
Colorado Central Zone
Datum: NAD 27

U.S. Department of Energy
Rocky Flats Environmental Technology Site

Prepared by: RADMS

Prepared for: KAISER•HILL COMPANY

File: w:\projects\2003\sw-2\remediation\olf pam.apr\olf features

Date: 01/24/04

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Disposal operations at the OLF ceased by the fall of 1968 possibly due to the Present Landfill (IHSS 114, located north of the IA) which began operation on August 17, 1968 (EG&G 1992a). The OLF waste material was covered with a soil layer after disposal operations ceased (EG&G 1994). Details on the placement of the soil cover layer, including exactly when it was constructed, are not available. Portions of the slope on the southern side of the landfill were later regraded to correct sloughing and erosion problems. Accurate and verifiable records of the wastes placed in the landfill are not available. However, approximately 74,000 cubic yards of sanitary waste and construction debris were disposed in the landfill (Kaiser-Hill 1996). These types of wastes likely included relatively small quantities of organics, paint and paint thinner, oil, pesticides, and cleaners (Rockwell 1988). Commonly used organics from 1952 to 1968 may have included trichloroethene, carbon tetrachloride, tetrachloroethene, petroleum distillates, 1,1,1-trichloroethane, dichloromethane, and benzene (Kaiser-Hill 1996). In the 1960s, the landfill may have received polychlorinated biphenyls (PCB) wastes (DOE 1992), such as carbonless copy paper, transformer and vacuum pump cleanup paper and rags, and small capacitors and fluorescent light bulbs. Metals such as beryllium, lead, and chromium, may also have been placed in the landfill (Rockwell 1988).

There is no information indicating that the OLF was used for routine disposal of radioactive material or other hazardous substance waste streams. During the period of operation of the OLF, several other areas within RFETS were used for the management and disposal of hazardous plant wastes, including radioactive waste. For example, some uranium wastes were buried in the east trenches, and drums with cutting oils and solvents were stored at the 903 Pad. These areas are described in the Historical Release Report (HRR) (EG&G 1992a) and subsequent annual updates. The majority of radioactive solid waste generated on site was disposed off site. Various controls and practices were used to segregate and manage radioactive wastes separately from plant sanitary waste and construction debris. Although the OLF was not operated for management or disposal of radioactive waste, information in the HRR and characterization results indicate that some waste contaminated with radioactive material, most notably wastes from buildings where depleted uranium (DU) operations were conducted, were disposed in the OLF. In addition, in 1965, 60 kilograms (kg) of DU were placed in the landfill after the DU, which was left on a pallet, reportedly ignited on a truck flatbed. The DU was probably covered with soil to extinguish the fire. Efforts were later made to retrieve the DU, however, only 40 kg were recovered. Further use of the affected area of the landfill was avoided (EG&G 1992a; DOE 1992). No record of any similar incident was found and workers have reported none. Further removal of DU in contaminated surface soil was completed in August 2004 leaving all surface soils below the ALs.

Activities listed for the OLF in October 1954 include its use as a burning pit for the plant (EG&G 1992a). Ash from the plant incinerator, graphite, used caustic drums, and general trash may have been dumped in the burn pit; however, no records of waste types have been found. Incinerator ash, for at least the first decade of plant operation, included ash derived from the incineration of combustible paper and other trash contaminated with low levels of DU surface contamination from Building 444, in addition to other combustible plant wastes (EG&G 1992a). Although some incinerator ash may have been disposed of in the OLF, the ash was routinely disposed of in several pits west of the OLF,

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namely, IHSS-133, the Incinerator Ash Pits. Based on investigation and characterization of the Incinerator Ash Pits, a RFCA No Further Accelerated Action (NFAA) determination was approved. (EPA 2003) Backwash water discharged from the water treatment plant passed through a drainage channel on the western side of the burn pit, and flowed down to Woman Creek. No information is available identifying the period of operation for the burn pit.

In 1995, Metcalf and Eddy conducted geotechnical investigations at the OLF as part of the OU-5 Phase 1 RFI/RI and described the fill material encountered during the investigation. The material consisted of waste mixed with varying amounts of sandy, clayey gravel and cobbles derived from colluvium and Rocky Flats Alluvium. The waste materials in the fill included sheet metal, wood, broken glass, plastic, rubber, metal shavings, graphite sand, solid blocks of graphite, concrete, asphalt, and portions of 55-gallon steel drums. The waste fill ranged in thickness from 2 ft to over 11 ft.

Seepage emerging from the OLF after a major rainstorm in July 1986 was traced to an outfall pipe from the Building 460 footing drains (EG&G 1992a). Sloughing of material in the area of the outfall occurred as a result and the hillside materials may have been washed into the South Interceptor Ditch (SID). To prevent migration of materials, a containment embankment was constructed to prevent flow into Woman Creek (EG&G 1992). The outfall piping was also extended to the east to discharge beyond the landfill boundary (refer to Section 2.4).

Street cleaning wastes were apparently dumped in the OLF area. The duration of use of this area for street cleaning wastes is not known. In March 1991, EPA requested that the dumping cease because it may exacerbate any groundwater and soil contamination and it was inconsistent with the planned CERCLA response (EPA 1991b). In July 1991, the contractor notified DOE that it had instructed the appropriate departments not to use the landfill as a dumping site for street sweeping litter or concrete truck washout (EG&G 1991).

2.3 Description and History of IHSS 196 (Filter Backwash Pond)

The water treatment plant Filter Backwash Pond was located on the hillside north of Woman Creek, approximately 800 ft south of the water supply treatment plant in Building 124 (EG&G 1992). The treatment plant treats water that is delivered from the Denver Water Board reservoir and ditch system to the raw water pond located north of the West Access Road to produce the plant's potable water. The Filter Backwash Pond, also known as Pond 6, was used as a retention pond to allow sampling of filter backwash water. It was also described as an evaporation and settling pond (EG&G 1992b). There is no record of sludge or sediment removal from the pond (DOE 1992b).

Pond 6 was constructed in 1955. However, water from the water treatment plant was discharged at the OLF before the pond was constructed. The HRR (EG&G 1992a) refers to an October 1954 reference that indicates backwash water from the water treatment plant flowed through the western side of the burning pit and down to Woman Creek. It is possible that Pond 6 was constructed in the location of the burning pit (EG&G 1992a). It

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is unclear when the Filter Backwash Pond was abandoned. By 1964, Pond 6 was no longer present, and the area was covered with fill (Kaiser-Hill 1996).

The effluent from the water treatment plant was discontinuous and probably made up of filter backwash, filter pre-wash, sludge blowdown, and other discharges from the water treatment process (EG&G 1992). It contained filterable solids removed from the raw water, as well as chemical flocculants (aluminum sulfate or lime) and residual chlorine (EG&G 1992).

2.4 Other Disturbances and Structures

Other disturbances and structures associated with IHSS Group SW-2 include a large surface disturbance located east of the landfill area, the SID, and two outfall pipes and their associated surface disturbances. An area of suspected surface disturbance and a possible pit were identified west of the landfill from a review of aerial photographs (EG&G 1994) (See Figure 2-1).

The surface disturbance area east of the landfill waste disposal area was also identified from review of aerial photographs for the OLF site (EG&G 1994). The area was active in the 1964 photography. Little historical information is available for this area; however, the area may have served as a storage yard for pipes and scrap metal (EG&G 1994). In the 1969 and 1971 aerial photographs, the area contains mounds of debris (EG&G 1994).

In 1980, the SID was built across the southern portion of the landfill (EG&G 1994). The purpose of the SID was to intercept runoff from the southern portions of the Rocky Flats Plant and divert the flow to Pond C-2. Two outfall pipes cross the OLF site. The original outfall pipe, constructed in 1986 (EG&G 1994), discharged storm water directly onto the landfill. This caused sloughing and sliding of the fill material. Slide material may have been removed from the SID and placed on the southern side of the gravel road constructed south of the SID (Metcalf & Eddy 1995). Sometime between 1986 and 1988, the original outfall pipe was abandoned and a new outfall pipe was constructed southeast across the OLF to discharge to the SID east of the landfill boundary. The buried outfall pipe discharges into a collection basin located east of the OLF. Sloughing, erosion, and construction of the outfall pipes may have exposed landfill waste at the surface.

2.5 Historical Interim Response Actions

Three separate response actions have been undertaken at the OLF. On July 23, 1979, contractors grading a road southwest of Building 444 outside the perimeter fence uncovered a portion of the landfill (EG&G 1992). The area was surveyed and three locations of depleted uranium were identified. One box of contaminated soil was removed (EG&G 1992).

The reach of Woman Creek adjacent to the western portion of the landfill was relocated because the creek threatened to erode into landfill materials (Singer 2002). Specific information on the relocation of Woman Creek, including when the creek was relocated, is not available.

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On June 7, 1990, EPA, CDPHE, and DOE staff conducted an inspection to evaluate previously identified exposed radioactive debris in the northwestern part of the OLF (EPA 1990). It is not known exactly when the debris became exposed; however, the area apparently was identified in April 1990 as a barrel containing radioactive materials (DOE 1990). A radioactive materials survey near the barrel encountered low levels of depleted uranium (EG&G 1990a). The area was roped off and access was restricted. Soil and water samples were collected and a requested radiological survey of the entire OLF area was subsequently conducted (EG&G 1990b). A gamma radiation survey conducted in late 1990 identified ten locations of elevated gamma radiation (Kaiser-Hill 1996).

A radiological survey with a Field Instrument for the Detection of Low-Energy Radiation (FIDLER) was also conducted at the OLF in 1993 as part of the OU-5 Phase 1 RFI/RI (EG&G 1994). Of the ten areas identified in 1990, the FIDLER survey did not identify any anomalous levels of radiation at seven of the locations. Within the bounds of two areas in the center of the OLF identified by the 1990 survey, nine areas of anomalous levels of radiation were found. These areas were posted as Radiologically Controlled Areas. Several pieces of radioactive material were removed from these areas on May 28, 1993, during an emergency removal action. The material removed included a 4- to 6-inch-diameter piece of concrete coated with a corroded metallic material, and several small (1- to 2-inch-diameter) spherical pieces of rusty material. The materials were removed for subsequent management as radioactive material (EG&G 1994). Analyses indicated that the materials contained depleted uranium. In those areas where a specific source of the anomalous radioactivity could not be identified, surface soil samples were collected.

Annual walkdowns of the landfill surface have been conducted each spring to search for classified items since 2000. No classified items have been found; however, several carbon molds have been removed from the area and appropriately dispositioned. Some of the items have exhibited very low levels of depleted uranium activity.

2.6 Slope Stability

Landslides have historically occurred at the OLF site within the colluvium and weathered bedrock prior to waste placement. During the 1995 geotechnical study, these historic areas of discrete landslides were identified in the OLF, as well as general areas of sliding (Kaiser-Hill 1996). In addition, the geotechnical study identified three potential slope failure mechanisms operating in the OLF area. These mechanisms are:

- Shallow landslides consisting of waste fill sliding on severely weathered claystone;
- Shallow landslides consisting of colluvium sliding on or with severely weathered claystone; and
- Deeper landslides consisting of movement within moderately weathered claystone at depths up to or approximately 35 ft, especially in areas of steeper slopes.

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Landslides on the claystone bedrock slopes beneath the alluvial surface probably commenced after the slopes were initially exposed by continued stream erosion through the pediment, rendering the overlying materials unstable and predisposing them toward movement. Aerial photographs of the Woman Creek drainage prior to the waste disposal support this theory by indicating that most landslides occurred prior to fill deposition. There is no indication of current landsliding or mass movement of the waste and soil fill. Additional geotechnical data have been gathered to further evaluate the stability of the OLF (see Section 3.4).

2.7 Existing Conditions

It has been approximately 36 years since disposal operations ceased at the OLF. The area now has well-established grasses and forbs, several stands of large trees, and several small areas of wetland vegetation. Most of the waste is currently covered by soil up to several feet thick; however, the surface of the area is hummocky, and some disposed materials are protruding from the ground in some areas. This indicates uneven waste and cover soil layer placement resulting in erosion and sloughing processes that uncover the wastes. The thickness and final grading and cover soil layer appears to be inadequate in a few places. There is no indication of current landsliding or mass movement of the waste and soil fill. There are no seeps in the area. Stormwater ponding occurs in several areas because of the surface topography. Several radionuclide contamination "hot spots" have been identified via surface soil sampling (refer to Section 4.3) and were removed in August 2004 (see Appendix C).

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3.0 ENVIRONMENTAL SETTING

3.1 Physiography

RFETS is located on the western margin of the Colorado Piedmont section of the Great Plains Physiographic Province at an elevation of approximately 6,000 ft (Kaiser-Hill 1996). The Colorado Piedmont is characterized as an area of dissected and denuded topography, representing an old erosion surface along the eastern margin of the Rocky Mountains. Several pediments (broad sloping planes formed by coalescing alluvial fans along a mountain front) developed across bedrock in the RFETS area during the Quaternary Period (Scott 1963). The Rocky Flats pediment is the most extensive of these pediments.

The RFETS IA is located on a relatively flat surface of the Rocky Flats pediment. The pediment surface has been eroded by Walnut Creek on the north and Woman Creek on the south. As a result, the pediment surface is located at an elevation of 50 to 150 ft above the creeks. The grade of the gently eastward-sloping surface of the Rocky Flats pediment ranges from one percent in the IA of RFETS to approximately two percent just east of the IA. Further east, the pediment's nearly flat-lying surface gives way to lower, gently rolling terrain of the High Plains section of the Great Plains Physiographic Province (Kaiser-Hill 1996).

Four ephemeral creeks drain the surface water from RFETS. Surface water that flows from the northern portion of RFETS is drained by Rock Creek, which is a northeast-trending tributary of Coal Creek. The central and southern portions of the site are drained by Walnut Creek, South Walnut Creek, and Woman Creek. These drainages are all tributaries of Big Dry Creek that flows eastward. Coal Creek separates all of the streams on the Rocky Flats pediment from the Front Range foothills. Surface water flow in these creeks is generally ephemeral; however, some reaches may support intermittent or perennial flow.

3.2 Climate

The climate at RFETS is characterized as semiarid (Kaiser-Hill 1996) with a mean annual precipitation of approximately 15.5 inches, based on 20-year means for Boulder and Lakewood, Colorado. The wettest season is spring (March through May), which accounts for approximately 40 percent of the annual precipitation, much of which is snow. Thunderstorms during the summer months provide another 30 percent of the annual precipitation. The precipitation gradually declines through the summer, fall, and winter (Kaiser-Hill 1996). Average annual pan evaporation in central Colorado is approximately 55 inches (DBS 2001).

The predominant wind direction at RFETS is northwesterly, and average wind speeds are under 15 miles per hour. Daytime heating causes upslope winds to form, with northeasterly winds common over the broad South Platte River Valley. More localized southeasterly winds also occasionally occur during the day at the Site because the terrain is oriented southeast toward Standley Lake and the city of Arvada. The winds reverse at

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night with a shallow, westerly drainage wind forming over the Site and a broad, southerly drainage wind forming over the South Platte River Valley (DOE 1999).

RFETS is noted for its strong winds. Gusty winds frequently occur with thunderstorms and the passage of weather fronts. The highest wind speeds occur during the winter as westerly windstorms, known as chinooks. The windstorm season at the Site extends from late November into April, with the height of the season usually occurring in January. The windstorms typically last 8 to 16 hours, with wind speeds exceeding 75 miles per hour in almost every season. Wind gusts exceeding 100 miles per hour are experienced every three to four years (DOE 1999).

3.3 Geology

Geologic units beneath the OLF consist of unconsolidated Quaternary deposits that lie unconformably over Cretaceous claystone bedrock. Six north-south cross sections were developed during the 1995 geotechnical study. One cross section, Figure 3-1, is typical of the other cross sections developed in the study. (EG&G, 1995; Kaiser-Hill, 1996) The unconsolidated surface deposits include the Rocky Flats Alluvium that dominates the surface of RFETS, colluvial materials that form the slopes of the Woman Creek valley, and valley fill materials on the bottom of the Woman Creek valley. These materials overlie the Laramie Formation bedrock (Metcalf & Eddy 1995). Geologic units in the OLF area are described below.

3.3.1 Rocky Flats Alluvium

The Rocky Flats Alluvium was deposited by a system of coalescing alluvial fans aggraded by debris flows and braided streams along the base of the Front Range at the mouth of Coal Creek Canyon (EG&G 1995). The alluvial deposits generally consist of beds and lenses of poorly sorted, clast- and matrix-supported, white-to-pink, sandy, cobbly gravel, gravelly sand, and silty sand (Kaiser-Hill 1996). The thickness of this unit ranges from about 3 to 30 ft in the areas where the pediment deposits overlie Cretaceous-aged bedrock (Kaiser-Hill 1996).

3.3.2 Colluvial Deposits

Colluvial deposits along the valley slopes at RFETS are middle Pleistocene to recent in age (Kaiser-Hill 1996). The colluvial material commonly consists of dark-gray to light, reddish-brown, silty sand, sandy silt, clayey silt, and silty clay that contains minor amounts of boulders and cobbles. The unit locally includes clast- and matrix-supported boulders and cobbles, and coarse to fine gravel in a silty-clay matrix. These materials are well graded to poorly graded and unstratified to poorly stratified. Clasts are typically subangular to subrounded, and their sedimentological composition reflects that of the bedrock and surface deposits from which they were derived. The thickness of the colluvial deposits ranges from 3 to 15 ft.

In the OLF area, the unconsolidated colluvial deposits consist of sandy, clayey gravel (derived from the adjacent Rocky Flats Alluvium) to sandy clay (Metcalf & Eddy 1995). The colluvium is frequently mixed with fill material in the landfill. Soil borings indicate

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the thickness of the colluvium ranges from 1 to 13 ft. The colluvium is damp to moist, although it can be wet near its contact with the Laramie Formation (Metcalf & Eddy 1995).

3.3.3 Valley-fill Alluvium

Valley-fill alluvium, located along the Woman Creek drainage, includes channel and terrace deposits related to the modern stream. These recent alluvial deposits are commonly grayish-brown, slightly cobbly, silty sand to sandy, clayey silt in the upper part, and poorly sorted, clast-supported, slightly cobbly, gravel in a light yellowish brown, clayey, silty sand matrix in the lower part (Kaiser-Hill 1996). Clasts are mostly subangular quartzite, with a minor amount of subrounded sandstone derived from older Quaternary deposits. The thickness of these deposits ranges from approximately 3 to 15 ft, with an average of about 10 ft.

During geotechnical investigations at the OLF (Metcalf & Eddy 1995), valley fill alluvium was encountered in three boreholes along the toe of the landfill. The alluvium consisted of medium dense-to-dense, sandy, silty, clayey gravel with cobbles. The alluvium ranged from 5 to 7 ft thick, and groundwater was encountered as shallow as two feet below ground surface (bgs).

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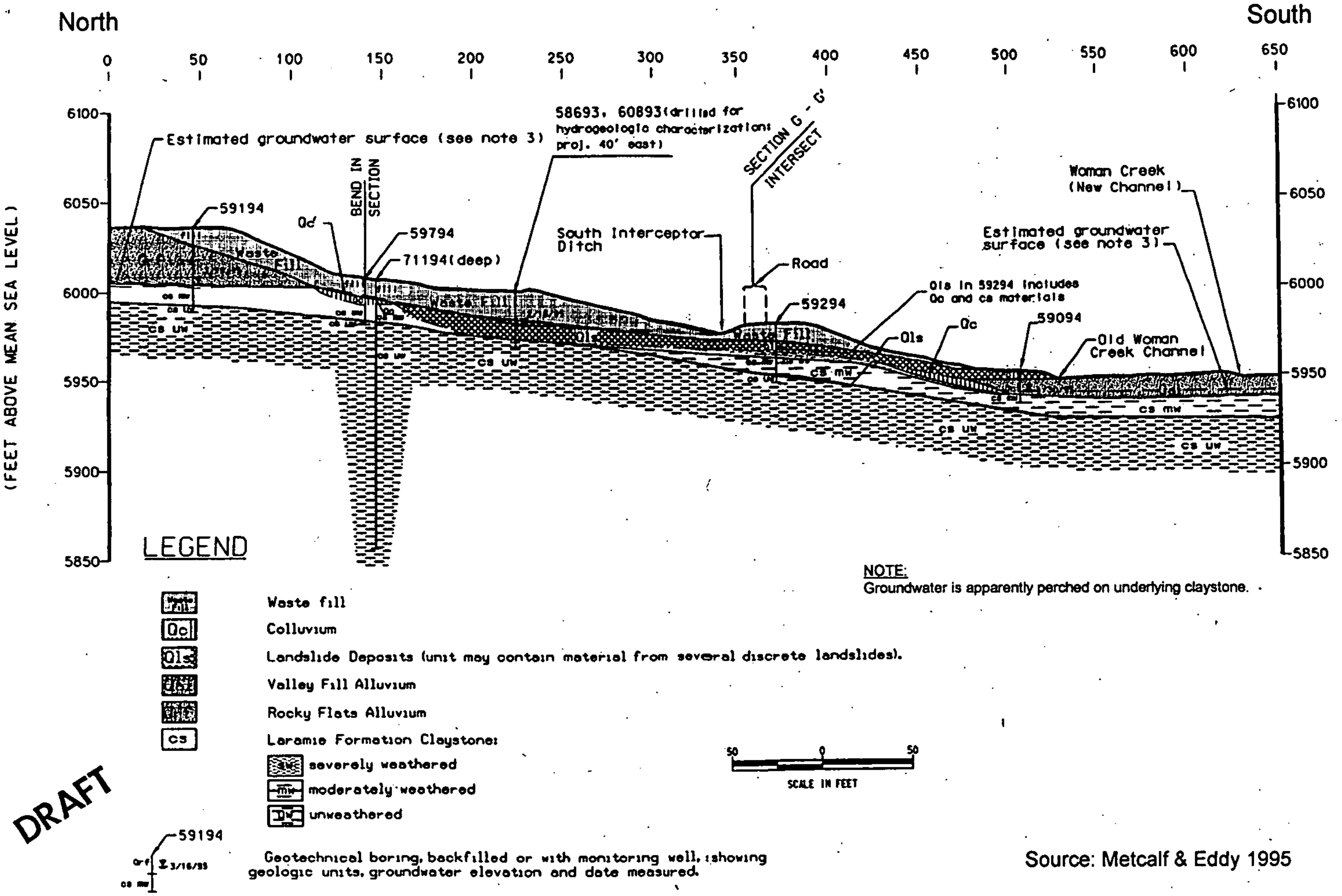
Figure 3-1 Typical Geological Cross Section of the Original Landfill



Source: Metcalf & Eddy 1995

3.3.4 Laramie Formation

Bedrock in the OLF area is Laramie Formation (Kaiser-Hill 1996). The Cretaceous-aged Laramie Formation is approximately 600 to 800 ft thick. It has been informally divided into upper and lower members (Kaiser-Hill 1996). The upper Laramie Formation is dominantly composed of fine-grained sedimentary rocks (primarily claystone with no thick sandstone beds). The upper part of the upper Laramie Formation is approximately 300 to 500 ft thick, and consists primarily of olive-gray to yellowish-orange claystone with large ironstone nodules. A few thin, discontinuous coal seams occur in the upper Laramie Formation. Lenticular beds of platey laminated or friable, calcareous, fine-grained, light olive-gray sandstone occur in the upper Laramie Formation, particularly in the upper portions of the formation.

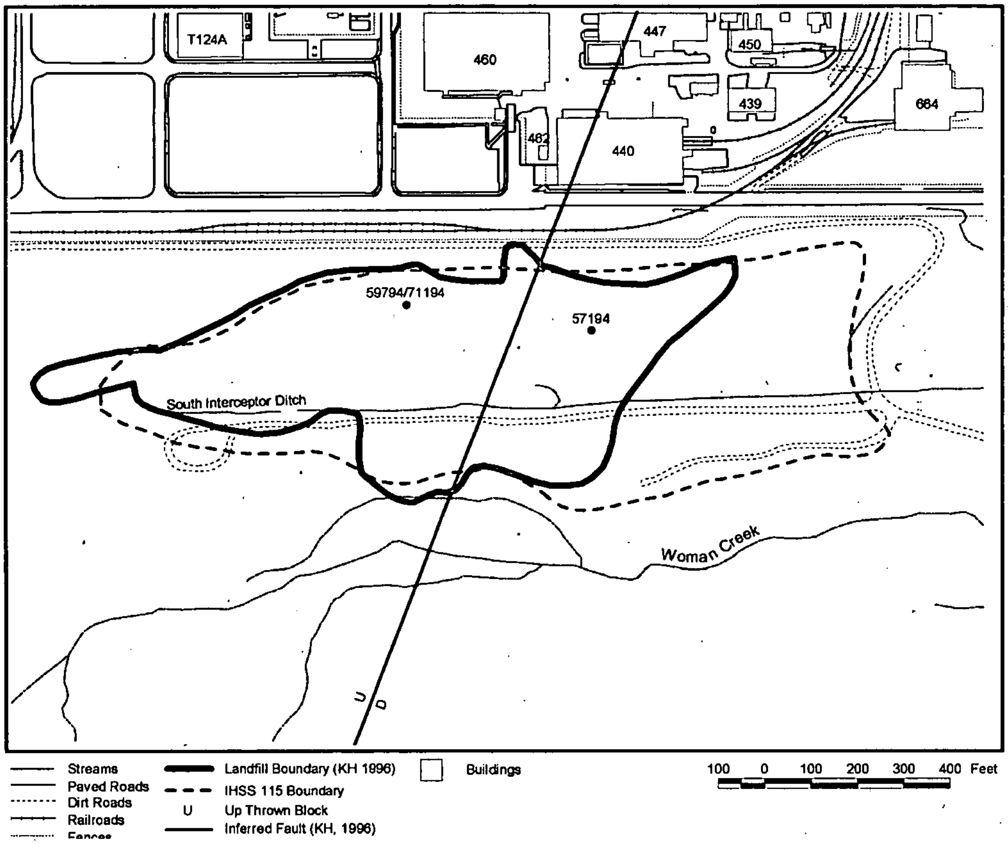
In the OLF area, the Laramie Formation is a weak claystone formation that underlies the soil-bearing slopes in the OLF (Metcalf & Eddy 1995). It is severely weathered (soft, plastic, and moist) in its near-surface aspect and underlies surficial materials in over 50 percent of borings. Moderately weathered Laramie Formation underlies the severely weathered Laramie Formation and is locally plastic, soft, damp, and fractured. It was encountered underlying surficial material in approximately 35 percent of the borings, indicating that the severely eroded Laramie Formation was sometimes displaced through sliding or erosion. The unweathered Laramie formation is the deepest component of the upper member and is similar to the moderately weathered Laramie Formation, although somewhat drier (Metcalf & Eddy 1995).

3.3.5 Inferred Faulting

Several inferred faults had been identified during site-wide geological investigations at RFETS (EG&G 1995). The longest of these is a northeast-trending reverse fault that extends from Woman Creek to Colorado Highway 128 across the western part of the IA. The fault plane is assumed to dip to the west. A borehole drilled into this fault, or fault zone, in another portion of RFETS filled with water within a few hours of drilling (EG&G 1995). The Geological Characterization Report (EG&G 1995, Figure 7-6) shows the fault trace going through the western side of the OLF.

The geotechnical investigation of the OLF (Metcalf & Eddy 1995) considered the presence of this fault. Metcalf & Eddy (1995) identified the bedrock fault as trending southwest from the vicinity of Building 371 through the OLF between borings 59794/71194 and 57194. The general location of the fault is shown on Figure 3-2. The location identified by Metcalf & Eddy (1995) and presented in the Final OU 5 RFI/RI Report (K-H 1996) goes through the center of the landfill. This location is based on the Systematic Evaluation Program (Geomatrix 1995). An evaluation of inferred faults in the vicinity concluded that this fault was not capable of generating future earthquakes (Geomatrix 1995). The fault is not expected to disrupt the engineering features or impact the structural integrity of the landfill, and does not appear to impact groundwater hydrogeology.

Figure 3-2 Inferred Fault in Original Landfill Area



3.4 Summary of Geotechnical Investigations

A geotechnical investigation conducted at the OLF in 1995 (Metcalf & Eddy, 1995) indicates some uncertainty of the stability of the landfill, and that landsliding of the soils, bedrock and/or waste may be possible. Within the scope and limitations detailed in the 1995 investigation, the work is considered quite thorough and comprehensive. Detailed field investigation of the landfill site was conducted; enabling sound geologic and geotechnical interpretation of site conditions, subsurface materials, and landsliding conditions. However, the laboratory strength testing of samples retrieved from the field investigation appeared somewhat limited, probably due to the preliminary nature of the study and also some sample recovery and disturbance problems in the weaker materials most desired for testing. Critical strength parameters for historical sliding at interface surfaces could not be determined through laboratory testing. Therefore, a back-calculation procedure was used in specific analyses, with an assumed factor of safety of 1.0 at failure for slope geometry and geotechnical parameters. Therefore, to further define the level of landfill stability and to support design of the accelerated action, a topographic survey of the current surface was obtained and a follow-up geotechnical investigation was conducted in 2004. The purpose of this second geotechnical investigation was as follows:

- Obtain and conduct geotechnical testing on materials that most affect the overall stability of the OLF area;

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- Assess the stability of the OLF and underlying soil and bedrock using the new geotechnical data;
- Assess the impact of groundwater on the underlying soil and bedrock stability; and
- Collect the required geotechnical information to design a long-term landfill stability monitoring plan.

The new geotechnical investigation data were also used to assess the structural stability impact of a buttress fill at the toe of the landfill slope. The following paragraphs summarize the follow up geotechnical investigation. A detailed presentation of the geotechnical data and stability analysis can be found in Geotechnical Investigation, Phase 3 Stability Analysis, Technical Support Memorandum (Earth Tech 2004).

There is no current evidence of landsliding or mass movement of the waste fill and soil; however, aerial photographs of the area prior to waste disposal suggest that the pre-landfill slope exhibited signs of previous instability and natural erosion. The current surface is uneven, with areas of sloughing and erosion resulting from historic landslides in the area prior to waste placement, poor waste management practices, and erosion and subsequent slope instability caused by poor surface water controls during and after waste placement operations.

The slope is approximately 90 to 100 ft high, as measured from the base of the landfill to the pediment surface. The upper 40 to 50 ft of the section consists of Rocky Flats Alluvium covered by 10 to 15 ft of waste and soil cover. The remaining 40 to 50 ft of the slope consists of moderately to severely weathered claystone overlain by various thicknesses of waste, constructed fill, and colluvium from past sliding.

The moderately to severely weathered claystone beneath and beyond the toe of the slope varies from 10 to 20 ft in depth and then transitions into unweathered claystone. At and beyond the toe of the slope, the weathered claystone is typically overlain by 5 to 10 ft of alluvium derived from the Woman Creek floodplain.

Groundwater within the slope generally occurs at or slightly above the claystone interface. It is locally higher near the middle of the fill due to ponding in closed depressions behind the fill and the poorly drained SID approximately located one-third the way up the OLF slope.

Waste was generally mixed with Rocky Flats Alluvium materials. The waste/soil matrix varies in consistency and generally consists of a range of silty gravel, clayey sand, and low-plasticity inorganic clay materials. Plasticity index values range from 17 to 31 percent. Effective shear strength values, estimated from soil descriptions, are estimated to be in the range of a friction angle of 30 degrees with a cohesion of 50 pounds per square foot.

Rocky Flats Alluvium is a generally dense, sandy, clayey gravel material with cobbles. However, it sometimes contains beds of stiff to hard clays and sandy clays, as well as fine, medium-dense to very dense clean to clayey sands. Laboratory tests by Metcalf and Eddy indicated the presence of low plasticity inorganic clay and high-plasticity inorganic clay materials with the low-plasticity inorganic clay materials having a plasticity index value of approximately 17 percent. Effective shear strength parameters are estimated, from soil

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descriptions and Metcalf and Eddy laboratory testing, to be in range of a friction angle of 37 degrees.

Colluvium located along and near the toe of the slope consists of a variety of materials from waste, Rocky Flats Alluvium, and weathered claystone materials. Tests by Metcalf and Eddy on clayey colluvium materials derived mainly from the weathered claystone materials indicated the presence of high-plasticity inorganic clay materials with plasticity index values in the range of 31 to 51 percent.

Moderately to severely weathered claystone is predominately classified as a high-plasticity inorganic clay material. Metcalf and Eddy laboratory tests indicated plasticity index values in the range of 30 to 52 percent.

Effective shear strength parameters for the colluvium and weathered bedrock from the recent geotechnical testing estimates a friction angle equal to 20 degrees (drained strength) and 15 degrees (undrained strength). These strengths are the lower bound of all the test data and assume no cohesion. However, these soils do exhibit cohesion ranging from an average of 410 to 510 pounds per square foot.

Tests were not conducted on the unweathered claystone materials because any sliding is expected to occur within the weaker weathered claystone layers above.

Further details of the followup geotechnical investigation are presented in the A detailed presentation of the geotechnical data and stability analysis can be found in Geotechnical Investigation, Phase 3 Stability Analysis, Technical Support Memorandum (Earth Tech 2004).

3.5 Groundwater

The uppermost groundwater is shallow, unconfined groundwater that occurs within the Rocky Flats Alluvium, colluvial deposits, valley fill alluvium, and weathered Laramie Formation. This water-bearing zone is referred to as the Uppermost Hydrostratigraphic Unit (UHSU) (EG&G, 1995). The UHSU is not an "aquifer" because it is not capable of yielding significant and usable quantities of groundwater to wells or springs (EG&G, 1995b). Soil borings in the Rocky Flats alluvium indicate that groundwater appears hydraulically disconnected from the lower hydrostratigraphic unit (LHSU) groundwater.

Characteristics and dynamics of the UHSU groundwater flow system at RFETS have been described in detail in the former Site-Wide Water Balance (SWWB) modeling work (KH, 2002). Results showed that UHSU groundwater at RFETS typically flows towards the nearest stream. Local flow rates and directions are strongly affected by the hydraulic properties of unconsolidated material, and the morphology and orientation of the underlying claystone bedrock and topographic surfaces. The shallow groundwater system is recharged mostly by direct infiltration of precipitation that is then mostly lost via evapotranspiration. As groundwater moves from higher elevations towards streams, an increasing amount is lost through evapotranspiration, and only a small amount actually contributes as baseflow to streams. Groundwater elevations typically vary seasonally less than 5 ft, mostly in response to direct precipitation recharge in wetter periods and evapotranspiration in warmer months. Water levels above the weathered bedrock range from 0 to 5 ft along Woman Creek; below the bedrock in the

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east-central waste area; 5 to 10 ft in the central waste area; 0 to 5 ft in the western waste area; and from 10 to more than 40 ft above the bedrock north of the OLF.

3.6 Integrated Hydrologic Model Development and Results

A fully integrated hydrologic flow model was developed to support evaluation of several possible closure configurations for the OLF (Integrated Hydro Systems 2004). The approach in developing a model for the OLF is similar to that described in the Site-Wide Water Balance (SWWB) modeling (K-H 2002). Current system flows are first simulated to demonstrate that assumed model parameter values are reasonable. Then specific changes are made in the model to simulate the integrated hydrologic system response to closure configuration modifications. The MIKE SHE code, developed by DHI (1999), is used to simulate integrated flows at the OLF. The code couples subsurface flows, unsaturated and saturated zone, with surface flows, overland and channel flow. Effects of evapotranspiration and snowmelt are also considered in the model, and output is generated subhourly over a full year.

Available geologic, hydrologic, and chemical data in the OLF and surrounding area were reviewed and then compiled into a spatial Geographic Information System (GIS) database to support model development. Most of this information was obtained from the former SWWB modeling, although several new datasets were prepared. Available field geologic borehole logs were carefully reviewed to define approximate waste and bedrock surface contacts. Recent logs for the area, along with a higher-resolution surface topography, were then used to construct more accurate weathered and unweathered bedrock surfaces in the OLF area than previously prepared (K-H 2002). Refinement of the weathered bedrock surface is important because this was found to strongly control groundwater flow gradients and levels in hillslope areas.

Thicknesses of unconsolidated material from the Building 440 area, south through the waste to Woman Creek, range from over 20 to less than 5 ft. Thickness of the waste material is also variable, ranging from less than 5 ft in the east-central area to more than 12 ft to the west. The unweathered bedrock thickness is generally about 20 ft through the OLF area.

More than 10 years of groundwater level data in the area, including recent 2004 data, were also reviewed. Groundwater level fluctuations within the OLF range from 5 to 10 ft over the year, reflecting seasonal recharge, evapotranspiration and drainage effects. The lack similarity between fluctuations in the OLF and those adjacent to the OLF suggests that unsaturated and saturated zone hydraulic properties of the waste area are similar to nonwaste areas. Groundwater depths in the UHSU range from about 20 to 30 ft below ground near the Building 440 area on the mesa to about 15 ft below ground within the waste, to less than about 5 ft below ground along Woman Creek. In the Lower Hydrostratigraphic Unit (LHSU) wells in the OLF area groundwater depths are significantly lower than in nearby UHSU wells (57194, 71194 are greater than 100 ft, suggesting the LHSU and UHSU are hydraulically disconnected in the area. Finally, a potentiometric surface map constructed using time-averaged water level information indicates there is a west-east groundwater divide just north of Building 444. Therefore, groundwater south of this divide slowly flows toward Woman Creek.

Several steps were involved in constructing the integrated flow model. First, a 25-ft numerical grid was prepared to better simulate local flow conditions associated with the OLF (a 200-ft grid

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resolution was used in the SWWB model.) Several GIS techniques were used to then convert spatial hydrogeologic GIS information onto the finer grid. Spreadsheet algorithms were then used to convert gridded GIS information into model input. Unsaturated and saturated zone hydraulic properties determined through integrated model calibration conducted for the original SWWB model and subsequent VOC fate and transport modeling (K-H 2004) were specified in the localized model. However, new values for drain conductances and hydraulic properties for the waste had to be determined through initial OLF model simulations.

The integrated model of the current system configuration, using climate data from October 1999 through September 2000 reproduces observed flow conditions well. Model simulations require that the Water Year (WY) 2000 climate sequence is cycled for three consecutive years to stabilize effects of prescribed initial conditions. Model performance is assessed by comparison of simulated and observed time-averaged water levels at well locations within the model area. Results indicate that average difference between simulated and observed levels within the OLF are less than one foot, and over the model area differences are just over a foot. At some well locations differences are greater than one foot, but can attributed to local scale effects not captured by the resolution of the model. Simulated annual surface flow at gage GS22, though less than observed, indicates most surface events are captured in peak flow, timing of events, snowmelt and baseflow. Additional adjustment of drain conductances would only improve the comparison between observed and simulated surface flows. Ultimately, the drain conductance values are not important in evaluating impacts of closure configurations on system flows because the drains are removed in these simulations.

Several closure configurations were evaluated as summarized below, including assumptions:

- Scenario 1 – IA Regrade-only
  - IA undergoes closure configuration (as per above)
  - No changes made to existing OLF area,
  - Typical climate year sequence assumed (WY2000).
- Scenario 2 – IA & OLF Regrade
  - IA undergoes closure configuration (as per above)
  - OLF area is regraded,
  - OLF area is re-vegetated,
  - Fill material is used as part of regrade (assume Qrf),
  - Typical and Wet Year (100-year basis) climate year sequences are assumed.
- Scenario 3 – IA & OLF Regrade, Fill Buttress, and Drain
  - Same as Scenario 2,
  - Includes Fill Buttress and Drain on Upgradient side.
  - Typical climate year sequence assumed (WY2000)

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- Scenario 4 – IA & OLF Regrade, Fill Buttress, Drain, and Slurry Wall
    - Same as Scenario 3, but includes slurry wall immediately north of the waste area footprint.

Scenario 1 was simulated to show the relative effects of regrading the OLF for a typical climate year sequence (that is, WY2000). Within the OLF, simulated average-annual groundwater levels change less than one foot. Locally they adjust less than three feet. The west-central area generally increases, while the east-central area tends to decrease in response to IA closure modifications. For example, pavement, buildings, drains and water supply lines are removed and then the IA is regraded and revegetated.

In Scenario 2 (basecase) OLF closure configuration scenario, both the IA and OLF are reconfigured. North of the OLF, the IA is closed as described above. Within the OLF, the ground surface is regraded and assumes a mature stand of vegetation. Regrading the OLF surface causes areas within the OLF waste to be filled up to 20 to 30 ft, and cut up to 20 ft. As a result, the depth to bedrock becomes both shallower and deepens throughout the OLF waste area, causing adjustments in groundwater levels in the area. Both a typical and 100-year wet-year climate sequence are simulated to show average hydrologic conditions within the model area as well as conservatively high levels.

Results of simulating the OLF regrade show an average increase in groundwater levels over the IA. Locally, levels increase up to seven feet and decrease less than 4 feet. The model also shows that average annual simulated depths in shallow bedrock areas rise to near ground surface (west-central area) for typical climate conditions. For wetter periods of a typical climate year, groundwater can discharge as seeps to the ground surface. Depths are greatest toward the eastern and western ends of the waste area because these areas represent fill areas associated with the regrade. Saturated heights above the weathered bedrock surface increase from 3 to 7 feet compared to Scenario 1. A water balance of the waste area to unweathered bedrock indicates that most of the direct precipitation infiltrates the surface soil, and then either evapotranspires or enters the groundwater system as recharge. Model results also show that variability in groundwater levels and flow within the hillslope are controlled by direct recharge and evapotranspiration, rather than by lateral inflow. Most of the discharge from the OLF occurs by evapotranspiration rather than lateral subsurface flow.

In the wet-year climate sequence average annual groundwater levels increase 0 to 0.4 meter over the waste area. This increases the saturated heights above the weathered bedrock a similar amount.

In the third scenario, effects of adding the fill buttress and upgradient drain have a limited affect on upgradient groundwater levels. For example, levels decrease an average of less than one foot over the waste area, but locally decrease more than 10 feet along the drain assumed to extend to the top of the weathered bedrock. Simulated drain discharge rates are less than 1 gpm. Effects of adding a slurry wall in the fourth scenario down to the top of the weathered bedrock also show only limited effects on both upgradient and downgradient groundwater levels. Average levels within the OLF decrease less than one foot. Locally, levels on the upgradient side increase less than three feet, and levels on the downgradient (south) of the slurry wall decrease less than three

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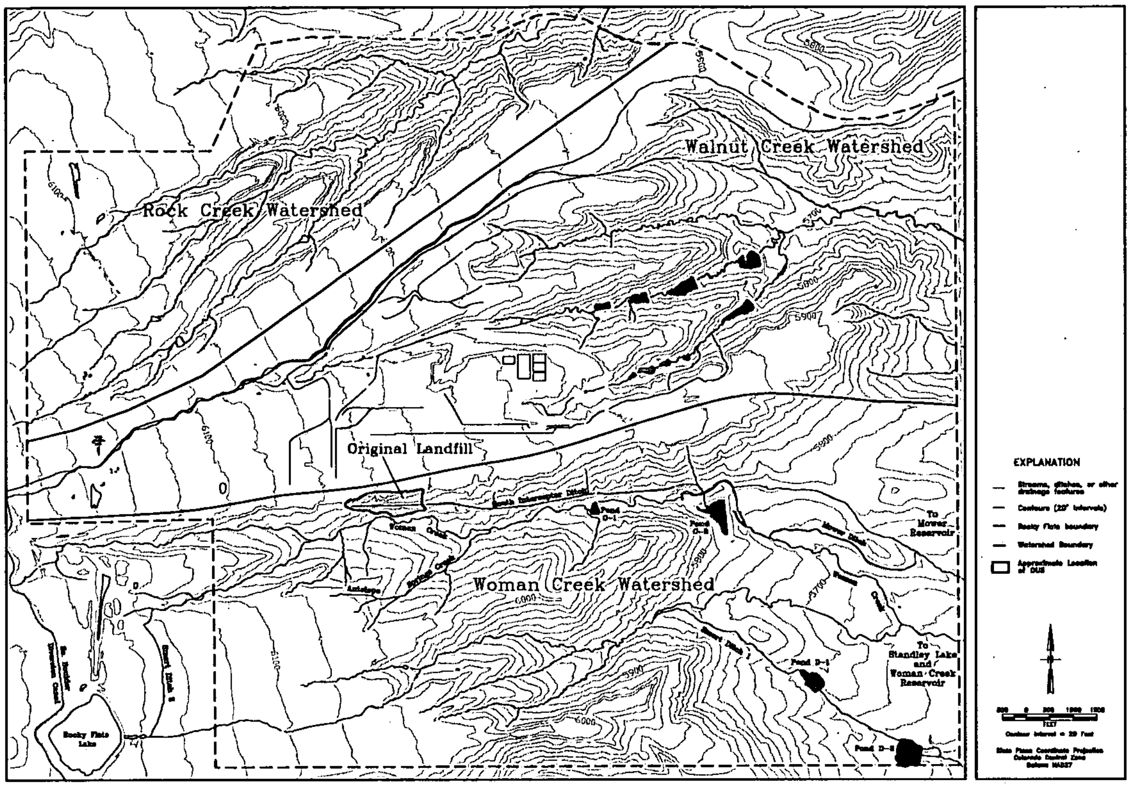
feet. The areal extent of change due to the slurry wall ranges from about 200 to 300 ft on either side.

3.7 Surface Water

The OLF is located within the Woman Creek drainage basin, which extends eastward from the base of the foothills near the mouth of Coal Creek Canyon to Standley Lake (Figure 3-3). The long-term average annual yield generated by this basin is 32.1 acre-ft, with average storms producing surface flows of 4 to 7 cubic ft per second (cfs). During extreme precipitation events (greater than the 15-year return occurrence based on precipitation), surface flows up to 40 cfs have been generated. Although seasonal flows can be low, Woman Creek receives continuous flow from Antelope Springs Creek. The reach of Woman Creek adjacent to the OLF is a gaining reach of stream (groundwater discharges to surface water); however, this inflow is likely due to inflow from the southern side of the valley and seepage from the old orchard area (Kaiser-Hill 1996).

The Woman Creek drainage basin has an artificial water control structure, the South Interceptor Ditch (SID), which intercepts runoff and routes it to Pond C-2. This runoff would normally flow into Woman Creek or percolate into the underlying subsurface materials of the basin. The Woman Creek diversion dam routes all Woman Creek flows less than the 100-year flood peak around Pond C-2 (Kaiser-Hill 1996). With the completion of the Woman Creek Reservoir, located just east of Indiana Street and operated by the city of Westminster, Woman Creek flows are detained in cells of the reservoir until the water quality has been ensured by monitoring of RFETS discharges via Woman Creek Reservoir into the Walnut Creek Drainage below Great Western Reservoir.

Figure 3-3 Surface Water Features



In the past, most natural flows in Woman Creek were diverted to Mower Reservoir and did not exit RFETS via Woman Creek. This is no longer the case. The Mower Ditch headgates were upgraded, and water in Woman Creek leaves RFETS via Woman Creek (at GS01) and enters the Woman Creek Reservoir. In the past, water from Pond C-2 (located off-channel in the Woman Creek drainage) was sampled and then pumped to the off-site Broomfield Diversion Ditch. Currently, RFETS discharges water from Pond C-2 directly into Woman Creek via a pump (at GS31); the water then flows to the Woman Creek Reservoir.

3.8 Ecological Setting

Even though the OLF is a highly disturbed industrial site, the area includes the Preble's Meadow Jumping Mouse (PMJM) protection area and wetland areas associated with surface water in the area. PMJM is listed as threatened by the U.S. Fish and Wildlife Service (USFWS). This listing provides special protection for the species under the Endangered Species Act, and potential remedial actions at the OLF must be evaluated for potential impacts to PMJM.

PMJM have been identified in all the major drainages of RFETS: Rock Creek, Walnut Creek, and Woman Creek, and the Smart Ditch drainages. Native plant communities in these areas provide a suitable habitat for this small mammal. PMJM at RFETS are restricted to riparian areas and pond margins, apparently requiring multistrata vegetation with abundant herbaceous cover. PMJM populations at RFETS are found in association with the riparian zone and seep wetlands across RFETS. The vegetation communities that provide PMJM habitat include the

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Great Plains riparian woodland complex, tall upland shrubland, wetlands adjacent to these communities, and some of the upland grasslands surrounding these areas. Recent studies have produced a better understanding of population centers of the species, and studies over the past several years have provided data to help estimate numbers of individuals within each population unit (RFETS 2000).

PMJM have been captured along Woman Creek in the area of the OLF where a significant amount of suitable habitat occurs. The PMJM were captured in riparian areas with well-developed shrub canopies and a relatively lush understory of grasses and forbs. This is typical of habitats occupied by the subspecies throughout its range (Kaiser-Hill 1996). The PMJM habitat and buffer area (Figure 3-4) includes a portion of the OLF area below the SID. The PMJM habitat and buffer area continues east-west along Woman Creek.

Jurisdiction wetlands in the OLF area are also shown on Figure 3-4, and include the area directly surrounding the SID. South of the landfill, wetland areas are associated with springs and riparian fringe in the Woman Creek drainage. The SID wetlands were created when the ditch was built, and may be considered isolated wetlands. The SID wetlands is a narrow, linear system, dominated by cattails and coyote willows and, as such, has lower functional integrity than the natural wetlands associated with Woman Creek.

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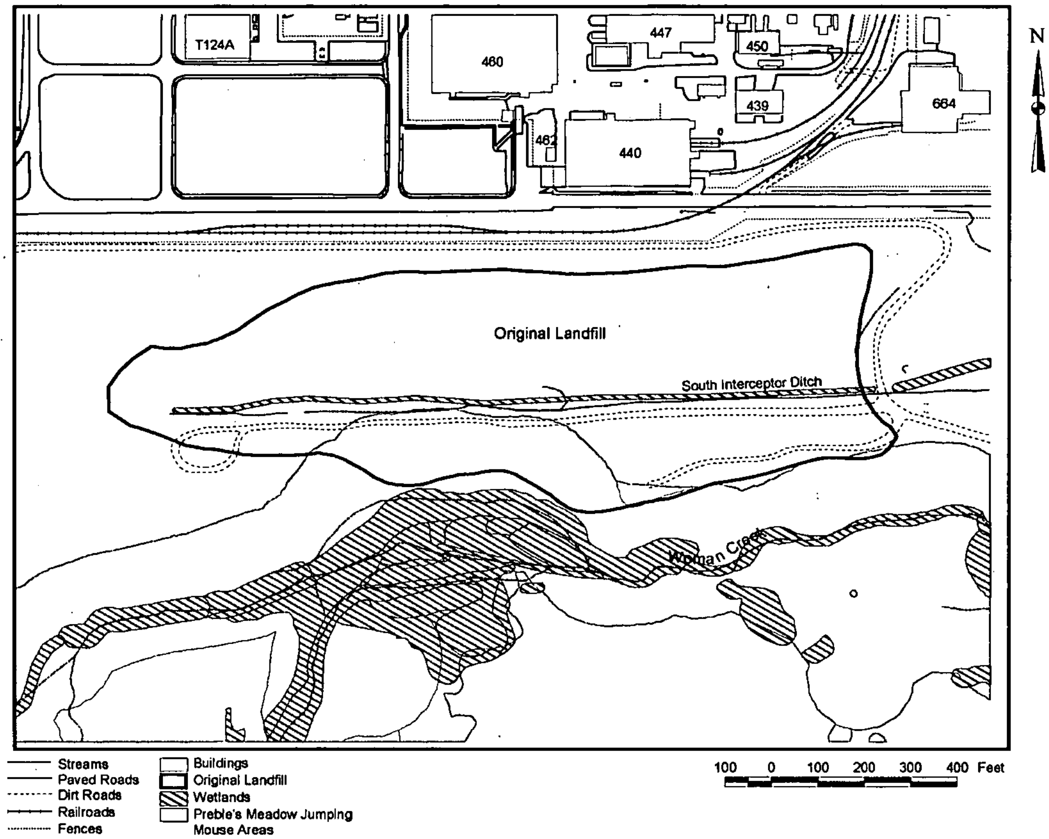
Figure 3-4 Wetlands and PMJM Areas Near the Original Landfill



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4.0 ENVIRONMENTAL DATA SUMMARY AND RFCA ACTION LEVEL COMPARISON

This section summarizes environmental data that have been collected at the OLF for surface soil, subsurface soil, groundwater, surface water, and sediment. Analyte concentrations are compared to Site background levels to determine potential contaminants, and are compared to RFCA Action Levels (ALs) to render accelerated action determinations in accordance with *RFETS Action Levels and Standards Framework for Surface Water, Ground Water and Soils*, RFCA Attachment 5 (ALF).

4.1 Site Characterization Data

The data used to characterize the nature and extent of contamination in and around the OLF were collected primarily in the early 1990s and are documented in the Operable Unit 5 (OU 5) Phase 1 Remedial Investigation/RCRA Facility Investigation (OU-5 Phase 1 RI/RFI) (Kaiser-Hill 1996). The OLF coincides with OU-5 Phase 1 RFI/RI Area of Concern 1 (see Figure 2-1).

Additional sampling of groundwater and surface water at or in the proximity of the OLF has occurred since that time. This additional sampling and analysis was planned and documented in accordance with the RFCA Integrated Monitoring Plan (IMP) (DOE et al. 1997). The RFCA Parties evaluate the IMP annually for adequacy and changes based on previous monitoring results, and changed conditions; planned activities and public input are made with the approval of CDPHE and EPA.

The scope of the OU 5 Phase 1 RFI/RI is presented in the OU 5 Phase 1 RFI/RI Work Plan (OU 5 Work Plan) (EG&G 1992). The OU 5 Work Plan includes the rationale for the number and location of samples. It was reviewed by EPA and CDPHE and subsequently approved and issued on February 28, 1992. Development of the OU 5 Work Plan included a Data Quality Objective process to describe the quantity and quality of data required. Data needs were identified to characterize the physical and hydrogeologic setting, assess the presence of contamination at each site, characterize the nature and extent of contamination, and support the evaluation of remedial alternatives based on effectiveness, implementability, and cost. The type, number, and location of samples were based on meeting these needs. Results of these investigations are contained in the 1996 RFI/RI Report for the OU 5 Woman Creek Priority Drainage (Kaiser-Hill 1996).

Sampling locations were selected based on earlier investigations and reviews of historical records, which included earlier groundwater and surface water analytical data, aerial photographs, site records, a magnetometer survey, and radiation surveys. All sampling and analysis activities were conducted in accordance with the Quality Assurance requirements of the OU 5 Work Plan. Data gaps were identified based on results of the earlier investigations, and additional sampling and geotechnical investigation was performed to fill these gaps.

The RFI/RI sampling program resulted in the following data related to the OLF:

- Surface soil: 7,568 validated analyses from 70 surface locations;
- Borehole samples to bedrock: 24,964 validated analyses from 175 soil samples;
- Groundwater: 31,171 validated analyses from 213 samples from 50 wells; and

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- Surface water: 25,384 validated analyses from 15 locations.

Investigations also included geotechnical evaluations, groundwater investigations, hydrogeologic testing, storm sewer sampling, and air monitoring. Other investigations conducted in the same time frame included the following:

- Field Instrument Detection Low Energy Radiation and High Purity Germanium gamma radiation surveys to detect and identify near-surface areas of contamination from radioactive materials;
- Magnetometer survey to locate ferrous materials and anomalies;
- Electromagnetic survey to delineate dump boundaries, saturated materials, and anomalies;
- Cone penetrometer tests to gather geotechnical information on the waste fill, alluvium, and bedrock.; and
- Soil gas survey for VOCs and combustible gases to locate possible sources of these constituents.

4.2 Data Compilation and Evaluation

The OU 5 Phase 1 RFI/RI Report fully compiles, discusses, and evaluates the results of all sampling activities at the OLF, as well as downslope/downgradient of the OLF. To simplify and focus the evaluation of the source containment presumptive remedy, only the RFI/RI analytical data that are directly relevant to the OLF IHSS were used in the action level comparison. These data include OU 5 RFI/RI surface and subsurface soil data for all sample locations within or immediately adjacent to the IHSS (Figures 4-1 and 4-2), groundwater data for Upper Hydrostratigraphic Unit (UHSU) wells within and downgradient of the IHSS (Figure 4-3), and surface water and sediment data for Woman Creek and the South Interceptor Ditch sampling locations closest to the IHSS (Figures 4-4 and 4-5). Groundwater and surface water data also include data that have been collected since the RFI/RI during routine sampling in accordance with the IMP. All data were extracted from the RFETS Soil Water Database (SWD).

Analytical data for surface soil (ending depth for the sample interval is 6 inches or less), subsurface soil (ending depth for the sample interval is greater than 6 inches), groundwater, surface water, and sediment have been compared to RFETS background levels. Background levels for metals and radionuclides in subsurface soil (geologic material of the UHSU), groundwater (total and dissolved[1] concentrations for the UHSU), surface water (total and dissolved concentrations for streams), and sediment are from the Background Geochemical Characterization Report (DOE 1993). Background values for surface soil are from the Geochemical Characterization of Background Surface Soils: Background Soils Characterization Program (DOE 1995). Because of difficulties in determining the appropriate background concentrations for organic compounds, any detection of an organic compound is considered an above-background observation. Results were determined to be "detect" or "nondetect" based on the result qualifier flags supplied by the laboratory.

The OLF data are summarized in Tables 4-1 through 4-7 for surface soil, subsurface soil, groundwater, upgradient Woman Creek surface water (stations SW039, SW040, SW041, and SW506), downgradient Woman Creek surface water (stations SW032, SW033, SW10295,

[1] For water, samples were split into "dissolved" and "total" based on whether the samples were filtered.

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SW50193, and SW50293), SID surface water (stations INT. DITCH, SW036, SW038, SW129, and SW500), and sediment (stations INT. DITCH, SW036, SED506, SED507, SED41400, and SED51693), respectively. These summary tables present only those analytes that were detected above background and the Method Detection Limit[2] in order to limit the tables to analytes that are potentially contaminants at the OLF. The entire analytical program for the samples addressed in Section 4.0 is summarized in Appendix B.

4.3 Surface Soil

As detailed in Table 1 of Appendix B, surface soil samples were analyzed for metals, radionuclides, volatile organic compounds (VOCs), semi-volatile organic compounds (SVOCs), pesticides, and PCBs. As shown in Table 4-1, metals, radionuclides, and organic compounds have been detected above background levels in surface soil; however, only uranium and a few polynuclear aromatic hydrocarbons (PAHs) are present in surface soil above the RFCA ALs.

Uranium contamination is present in surface soil above the ALs at four sample locations. As shown on Figure 4-6, one sample location is on the northwestern boundary of the OLF. This area was initially identified by gamma radiation surveys, which indicated it was a small, localized area of contamination. The uranium contamination at this location coincides with the action discussed in Section 2.5 for debris that became exposed at the surface in April 1990, which was surveyed and determined to be contaminated with depleted uranium. It was further investigated in accordance with the OU-5 Work Plan.

The other three sample locations where uranium concentrations are above the ALs are at the center of the landfill (Figure 4-6). Elevated gamma radiation in this area was initially identified by the 1990 gamma radiation survey and was further investigated in accordance with the OU 5 Work Plan. The OU 5 Work Plan gamma survey identified nine areas of elevated radiation roughly bounded by the surface soil locations with the above AL uranium concentrations. As discussed in Section 2.5, debris was removed from this area in May 1993 during the OU 5 gamma survey. The uranium contamination at this location could also be a remnant of the depleted uranium cleanup operation that occurred in response to the dumping of 60 kg of burnt depleted uranium, as discussed in Section 2.2.

Examination of the uranium isotope concentrations shown on Figure 4-6 indicates that the four sample locations with uranium isotope concentrations above the ALs have a uranium-238/uranium-234 activity ratio of approximately 10, which is indicative of depleted uranium.[3] The other above-background concentrations of uranium in the area have associated uranium-238/uranium-234 activity ratios that are lower, in some cases as low as approximately 1, which is indicative of natural uranium.

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[2] For the Section 4 summary tables, an analyte is not listed if the maximum concentration does not exceed background and the Method Detection Limit (MDL) listed in Appendix E of the Industrial Area and Buffer Zone Sampling and Analysis Plan (IABZSAP) (DOE 2004). This MDL may differ from the reported sample MDL. The IABZSAP MDLs are considered representative of what most laboratories can achieve and have been used because the MDL originally reported could have been either an Instrument Detection Limit (IDL), MDL, or Reporting Limit (RL) (supporting documentation is unclear). A "U qualified" result is always considered a non-detect regardless of whether the value exceeds the IABZSAP Appendix E MDL because the laboratory reported it as a nondetect.

3 The U238/U234 ratio of 10 is based on the weight fractions of the isotopes in depleted uranium as provided in the 1988 DOE Publication l "Health Physics Manual of Good Practices for Uranium Facilities" (Bryce et al. 1988). They are as follows: uranium-238 – 0.9975; uranium-235 – 0.0025; uranium-234 – 0.000005. These were converted to activity fractions using the specific activities of the isotopes. The activity fractions are as follows: uranium-238 – 0.903; uranium-235 – 0.015; and uranium-234 – 0.083. As can be seen, the uranium-238/uranium-234 activity ratio is approximately 10.

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Surface soil removal and confirmation sampling have been conducted at these four locations with uranium isotope concentrations above the ALs. A description of the soil removal and confirmation sample results are presented in Appendix C.

With respect to the PAHs, as shown on Figure 4-7, these compounds are ubiquitous in surface soil at the OLF. However, two sampling locations have PAH concentrations that exceed the ALs, and one of these locations shows an exceedance with a wide margin above the AL (benzo[a]-pyrene at SS10593). PAHs are largely confined to the surface (Section 4.4), likely due to PAH-contaminated runoff from paved areas in the IA that contacted the soil or from the dumping of street sweeping materials on the surface of the OLF, as discussed in Section 2.2.

4.4 Subsurface Soil

As detailed in Table 1 of Appendix B, subsurface soil samples (soil mixed with buried waste) were analyzed for metals, radionuclides, VOCs, SVOCs, pesticides, and PCBs. As shown in Table 4-2, metals, radionuclides, and organics have been detected above background levels in subsurface soil; however, only PAHs were detected above the ALs. PAHs were detected in subsurface soil in a relatively isolated location as shown on Figure 4-8. Unlike the widespread detection of PAHs in surface soil that probably indicates runoff from asphalt-paved areas in the IA as a potential source, the isolated occurrence of PAHs in subsurface soil appears to indicate the presence buried wastes and possibly asphalt and street sweepings.

4.5 Groundwater

As detailed in Table 2 of Appendix B, groundwater samples were analyzed for metals, radionuclides, VOCs, SVOCs, pesticides, PCBs, and water quality parameters (WQPs). Seventeen years of data exist for radionuclides, VOCs, and WQPs (1986 to 2003). There are metals data from 1991 to 2003, and SVOC and PCB/pesticide data mostly from 1991 to 1995. The SVOC and PCB/pesticide data collection was discontinued because these compounds were largely not detected. As shown in Table 4-3, metals, radionuclides, and organic compounds have been detected in groundwater at concentrations above background and the Tier II ALs.[4] However, the number of detections above background and the Tier II ALs was generally very low for all of these constituents, and their concentrations were also generally very low relative to background and the Tier II ALs. This is further evaluated below.

4.5.1 Metals

Antimony, beryllium, cadmium, lead, manganese, nickel, selenium, and thallium were detected above the Tier II AL at least once in groundwater at the OLF (Table 4-3). Metal concentrations did not exceed the Tier I AL. The metal concentration distributions over time for those wells where there was one or more detections above the Tier II ALs are discussed below.

Antimony As shown on Figure 4-9, wells 5786, 59593, and P416689 had concentrations of antimony that were above the Tier II AL. However, concentrations were above background only

[4] Dissolved concentration data are presented in Table 4-3 for metals and radionuclides because these data are representative of the mobile fraction of these constituents in groundwater. Total concentration data are presented for organics because these samples are not field filtered in accordance with standard operating procedures.

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once for each well, and the most current data for each well indicate concentrations were below the Tier II AL.

Beryllium Figure 4-10 indicates well 7086 had concentrations of beryllium that were above the Tier II AL. There were two occurrences in the late 1980s and all subsequent measurements have been non-detects or at trace levels well below the Tier II AL.

Cadmium Figure 4-11 shows that wells 7086 and 10994 had concentrations of cadmium that were above the Tier II AL. There was one occurrence in each well in the early to mid-1990s and all subsequent measurements have been nondetects or at trace levels well below the Tier II AL.

Lead Figure 4-12 indicates well 5786 had a concentration of lead that was above the Tier II AL. There was one occurrence in 1990 and all subsequent measurements have been nondetects or at trace levels well below the Tier II AL.

Manganese As shown on Figure 4-13, four wells had manganese concentrations above the Tier II AL. With the exception of well 59493, each well had concentrations that were either inconsistently above the Tier II AL or within a factor of 2 of the Tier II AL. Manganese concentrations in groundwater at well 59493 had consistently exceeded over the Tier II AL, and the concentration was over 10 mg/L in 1993. However, subsequent measurements indicate the concentrations are within a factor of 2 of the Tier II AL (approximately 3 mg/L).

Nickel As shown on Figure 4-14, four wells had nickel concentrations above the Tier II AL. However, for two of these wells (5786 and P416689), the concentrations were inconsistently above the Tier II AL. For the other two wells (57994 and 58194), there was only one sample for each well, and the concentrations were within the range seen at well P416689, which is an upgradient well.

Selenium As shown on Figure 4-15, two wells had selenium concentrations above the Tier II AL. The concentration in well 59793, located within the OLF, was just above the Tier II AL (and background); this was the only sample for this well. The other location where the selenium concentration was above the Tier II AL is well 10994, an IMP Plume Extent monitoring well, located east of the OLF (Figure 4-3). As shown on Figure 4-15, dissolved selenium concentrations were relatively high, averaging approximately 0.6 mg/L. These concentrations are 10 times the Tier II AL and background. Well 10994 is sidegradient to the OLF. Therefore, the OLF does not appear to be the source for the selenium observed at this location.

Thallium As shown on Figure 4-16, eight wells had thallium concentrations above the Tier II AL. However, in every well, rarely did the concentrations exceed background (background is over 2 times higher than the Tier II AL), and every above-background concentration was within a factor of 2 of the background value.

4.5.2 Radionuclides

Americium-241, strontium-90, uranium-235, and uranium-238 were detected above background and the Tier II AL at least once in groundwater at the OLF (Table 4-3). Uranium-234, plutonium-239/240, radium-226, radium-228, cesium-137, and tritium were not detected above background and the Tier II AL. Because americium-241 was only detected above the Tier II AL

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(and background) once in 26 samples, and at a relatively low activity (0.74 pCi/L), the occurrence of this radionuclide in groundwater at the OLF is not evaluated further[5]. The activity distributions over time for the other radionuclides in wells that had one or more detections above the Tier II ALs are discussed below:

Strontium-90 As shown on Figure 4-17, five wells had strontium-90 activities above the Tier II AL. However, in all the wells, the concentrations were inconsistently above the Tier II AL, and the most recent samples had activities below the Tier II AL.

Uranium Uranium-235 exceeded background and the Tier II AL, and uranium-238 exceeded background and the Tier I AL in well 61093. Uranium isotope concentrations in all other wells were below background.

To further evaluate whether the uranium in groundwater is naturally occurring, the total uranium concentrations (sum of uranium-234, uranium-235, and uranium-238) and the U-238/U-234 activity ratios for well 61093 were plotted (Figure 4-18). As shown on Figure 4-18, a trend of increasing U-238/U-234 ratio with increasing concentration exists, which indicates the presence of depleted uranium. (Depleted uranium has a U-238/U-234 activity ratio of approximately 10, whereas natural uranium has an activity ratio of approximately 1.) On Figure 4-19, the total uranium concentrations and the U-235/U-238 mass ratios are plotted. (The U-235/U-238 mass ratios were calculated from alpha spectrometer data for the two uranium isotopes.) This figure indicates the U-235/U-238 mass ratio decreased significantly when the total uranium concentration increased significantly. This also suggests the presence of depleted uranium because natural uranium has a U-235/U-238 mass ratio of 0.0072, and ratios significantly less than this value indicate a lesser proportion of uranium-235 is present, that is, depleted uranium.

As part of a Sitewide study on the occurrence of uranium in groundwater, sample from wells 59393, 59793, and 61093 were collected and analyzed for uranium-234, uranium-235, uranium-236, and uranium-238 using Inductively Coupled Plasma/Mass Spectrometry (ICP/MS) (data not included in Table 4-3). This analytical method provides uranium isotope concentrations in parts per billion (ppb). Samples from these three wells were collected on June 22, 1999, December 7, 1999, February 8, 2000, and June 12, 2000. The average total uranium concentrations and the average uranium-235/uranium-238 mass ratios are plotted for these wells on Figure 4-20. The results indicate the average total uranium concentrations were low in wells 59393 and 59793 (< 100 ppb), and the average uranium-235/uranium-238 mass ratio was approximately 0.0072, indicating the presence of natural uranium. In contrast, in well 61093, the average total uranium concentration was much higher (approximately 600 ppb or 200 pCi/L),[6] and the average uranium-235/uranium-238 ratio was much lower (0.0024), indicating depleted uranium is the source of the observed higher uranium concentrations. Also, uranium-236 was not detected in wells 59393 and 59793, but was detected in the groundwater samples from well 61093. The uranium-236 concentrations reported for the sample collection dates noted above were 0.015 ppb, 3.701 ppb, 0.027 ppb, and 0.017 ppb, respectively. Because uranium-236 is not a naturally

[5] The single occurrence of americium-241 above the Tier II AL was in well 7086, a downgradient well. It occurred during the first sampling of the well in 1987; the four subsequent samples from the well indicated nondetectable americium-241 activities.
[6] Dissolved concentration data were not collected in 1999 and 2000. Therefore, the results presented on Figure 4-20 (total concentrations in 1999 and 2000) cannot be compared to results presented in Figures 4-18 and 4-19 (dissolved concentrations in 1995).

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occurring isotope of uranium, this further suggests the presence of depleted uranium at well 61093.

Considering the above results and the location of well 61093 within the bounds of the depleted uranium "hot spot" in surface soil, the "hot spot" appears to be the source of the depleted uranium contamination in groundwater. However, for perspective, it is noted that the dissolved uranium concentrations at well 61093 are at or near background concentrations (approximately 100 pCi/L of dissolved uranium).

4.5.3 Organics

Table 4-3 indicates that organic compounds, primarily chlorinated solvents, are occasionally detected in groundwater in or near the OLF, generally at very low concentrations (<10μg/L). Compounds with concentrations that have been above the Tier II AL include dieldrin, bis(2-ethylhexyl)phthalate, 1,1,2,2-tetrachloroethane, 1,1-dichloroethene, methylene chloride, tetrachloroethene (perchloroethene or PCE), and trichloroethene (TCE). The organic compound concentration distributions over time for those wells that had one or more concentrations above the Tier II AL are discussed below. [Note that the concentration distributions over time for 1,1,2,2-tetrachloroethane and 1,1-dichloroethene are not shown or discussed because only a single occurrence above the Tier II AL for each compound was detected, and the concentrations were less than 10 μg/L.[7] The concentration distribution over time for methylene chloride is also not shown because the seven concentrations above the Tier II AL are isolated occurrences in seven different wells. Methylene chloride is also a common laboratory contaminant.

Dieldrin Four occurrences of dieldrin, a pesticide, were reported at concentrations above the Tier II AL. As shown in Figure 4-21, all four occurrences were in well 10994, and they represent all the dieldrin data for this well. The data were collected in 1994 – 1995, and they appear to indicate a decreasing concentration trend. Regardless, the well is sidegradient (to the east) of the OLF (see Figure 4-3) and, therefore, the OLF is not the source of the apparent dieldrin contamination.

Bis(2-ethylhexyl)phthalate Bis(2-ethylhexyl)phthalate was detected above the Tier II AL in wells 58194, 59393, and 59493 (Figure 4-22). The three exceedances are not representative of the balance of the data at these wells, which indicate the compound is rarely detected or detected at a very low level below the Tier II AL. Furthermore, the qualifier code on the data for the three concentrations above the Tier II AL indicates the compound was detected in the laboratory blanks. It is concluded that the OLF is not a source for bis(2-ethylhexyl)phthalate in groundwater.

Tetrachloroethene As shown on Figure 4-23, seven wells contained PCE concentrations above the Tier II AL (see Figure 4-3 for well locations). In three of the wells (60893, 63193, and P416689), the PCE concentrations were near or below the Tier II AL over time. Because P416689 is an upgradient well (to the north, up the hillside [see Figure 4-3]), it appears the

[7] 1,1,2,2-Tetrachloroethane was detected in well 58094 at a concentration of 3 μg/L in 1994. This compound was not detected in this well again, or in any other well at the OLF. The 1,1-dichloroethene concentration above the Tier II AL was for a sample collected from well 61093 in 1993 (31 μg/L). Two subsequent samples from this well in 1995 contained 1,1-dichloroethene concentrations of 5 μg/L and nondetected.

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source of this low-level PCE contamination is the IA. The four other wells at the OLF with PCE concentrations above the Tier II AL had significantly higher levels of this VOC. Three of these wells are located within the OLF (58693, 59194, and 59794 [west-northwest of the OLF center]). There is one data point each for wells 58693 and 59794, and three data points for well 59194. Concentrations of PCE are in the 8 to 150 µg/L range. The fourth well with significantly higher PCE concentrations (62893) is located sidegradient of the OLF (to the east) and has an apparent steadily increasing concentration of PCE in the same concentration range noted above. Because of the sidegradient position of the well, it appears the source of the PCE contamination at this location is the IA. In summary, PCE contamination in groundwater at the OLF results from IA activities; there may be additional minor PCE contamination arising from the OLF.

Trichloroethene Similar to the occurrence of PCE in groundwater, eight wells contained TCE concentrations above the Tier II AL (Figure 4-24) (see Figure 4-3 for well locations). In five of the wells (20697, 59594, 62893, 63193, and P416689), TCE concentrations were near or below the Tier II AL over time. Because 62893 is a sidegradient well and P416689 is an upgradient well [see Figure 4-3]), it appears the source of this low-level TCE contamination is the IA. The three other wells (60993, 61093, and 59794) contained significantly higher concentrations of TCE. Although well 61093 had a maximum TCE concentration of 140 µg/L, the concentrations continually dropped off in the subsequent three sampling events at this well, with only 2 µg/L of TCE reported in the last sample collected from this well (June 2004). There is one datum for well 60993 (85 µg/L) and well 59794 (20 µg/L). In summary, TCE contamination in groundwater at the OLF arises from the IA, and there may be additional minor TCE contamination arising from the OLF.

4.5.4 Water Quality Parameters

Nitrate was the only WQP with concentrations above the Tier II AL. As shown on Figure 4-25, nitrate was detected above the Tier II AL once in well 7086. This occurrence of nitrate above the Tier II AL was back in the late 1980s, and all subsequent occurrences were near the detection limit or not detected. The data indicate the OLF is not a source for nitrate contamination of groundwater.

4.5.5 Groundwater Quality Summary

In summary, groundwater quality is not significantly impacted by the OLF. The OLF does not appear to be a source for metal contamination. Uranium concentrations are near background levels even though there appears to be depleted uranium contamination at well 61093, and there may be minor chlorinated solvent contamination arising from the OLF. Furthermore, as shown in Figure 4-25, chlorinated solvent contamination in groundwater does not extend downgradient of the OLF. The most recent VOC data for these wells (last 3 years) indicate chlorinated solvents are either not detected or detected at trace concentrations below 1 µg/L, that is., a chlorinated solvent plume is not emanating from the OLF.

4.6 Surface Water

As detailed in Table 3 of Appendix B, surface water samples were analyzed for metals, radionuclides, VOCs, SVOCs, pesticides, and WQPs. Surface water quality data have been

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evaluated through comparison to RFETS background levels and surface water ALs, and also through comparison to upgradient conditions. The latter analysis was performed to evaluate local changes in surface water quality in Woman Creek as it passes beside the OLF.

4.6.1 Upgradient Woman Creek Surface Water Quality

As shown in Table 4-4a, several metals, radionuclides, and organic compounds have been detected within Woman Creek with total concentrations above background levels in surface water upgradient of the OLF. The concentrations of some of these constituents were occasionally above the surface water ALs. The highest frequency of concentrations above the surface water ALs was for methylene chloride (approximately 20 percent), followed by lead (approximately 15 percent). The frequencies of concentrations above the surface water ALs were less than 5 percent for the remaining analytes. Methylene chloride is a common laboratory contaminant, and was present in the associated laboratory blank for most of the reported methylene chloride detections. The surface water AL and background value for lead are virtually the same, explaining the occasional concentrations that were above the surface water AL.

As expected, there were fewer dissolved metals and radionuclides with concentrations that exceeded the surface water ALs (Table 4-4b). The frequencies of concentrations above the surface water ALs were less than approximately 5 percent for these analytes.

In summary, there are no significant impacts to Woman Creek water quality upgradient of the OLF.

4.6.2 Downgradient Woman Creek Surface Water Quality

As shown in Tables 4-5a and 4-5b, similar to upgradient Woman Creek water quality, several metals, radionuclides, and organic compounds have been detected above background levels within Woman Creek surface water downgradient of the OLF. The concentrations of many of these analytes were occasionally above the surface water ALs (approximately 5 percent or fewer of the observations), and were generally low in magnitude relative to the surface water ALs. Comparing Tables 4-4a and 4-5a, several metals and organics that were detected above background in surface water downgradient of the OLF have not been detected above background in upgradient surface water. However, these analyte concentrations typically were low relative to the surface water ALs, with only infrequent concentrations above the surface water ALs. If these additional detections can be attributed to the OLF, fewer than 7 percent of any analyte sampled exceeded the AL. This frequency of occurrence is not sufficient to indicate the OLF has a significant chronic impact on surface water quality.

Even though TCE and PCE are present in groundwater at the OLF, the following observations regarding these compounds in Woman Creek surface water are noted to underscore the lack of a chronic impact, if any, from the OLF on Woman Creek water quality:

- PCE (2 μg/L) and TCE (3 μg/L) were detected at SW033 on April 11, 1990. These compounds were not detected at this station in 10 previous and 19 subsequent sampling events.

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- TCE (26 μg/L) was detected at SW032 on November 11, 1987. TCE was not detected at this station in 3 previous and 28 subsequent sampling events.

4.6.3 South Interceptor Ditch Surface Water Quality

As shown in Tables 4-6a and 4-6b, similar to upgradient and downgradient surface water quality in Woman Creek, several metals, radionuclides, and organic compounds have been detected above background levels in the South Interceptor Ditch (SID) surface water. Generally, the concentrations of many of these analytes have been occasionally above the surface water ALs (approximately 5 percent or less of the time), and are low in magnitude relative to the surface water ALs. However, a notable difference between SID surface water quality and Woman Creek surface water quality is evident in the occurrence of barium and the uranium isotopes.

Of the metals, barium has the highest frequency of exceeding background in SID surface water at well over 50 percent of all observations. However, the barium concentrations exceed the surface water AL in only one observation. Table 4-3 indicates barium concentrations are also frequently above background in groundwater. Groundwater infiltration to the SID may be a plausible explanation for the above-background barium concentrations in SID surface water. Barium concentrations in OLF groundwater rarely exceed the Tier II groundwater AL.

Unlike Woman Creek surface water, a relatively high frequency of above-background concentrations for the uranium isotopes (total and dissolved concentrations [Table 4-6a and 4-6b]) exists in the SID, which occur at SW036 only (see Figure 4-4 for station location). The other stations on the SID have low concentrations of uranium (< 5 pCi). Uranium-238, particularly the total concentration (see Table 4-6a), also has frequently exceeded the surface water AL. (The surface water AL is for the sum of the isotopes.) As shown on Figure 4-27, uranium concentrations (sum of the isotopes) at SW036 are typically 30 to 40 pCi/L (total, as opposed to dissolved concentrations), and are rarely below the drainage-specific surface water AL of 11 pCi/l. Also shown on Figure 4-27 are the U-238/U-234 ratios, which are typically about 3. As discussed in Section 4.5 for groundwater, this elevated ratio indicates a depleted uranium component in surface water at this station. As discussed previously, depleted uranium contamination exists in surface soil and in groundwater at well 61093. The depleted uranium contamination at SW036 probably arises from both contaminated runoff and discharge of groundwater to the SID (interflow).

Data presented by K-H (2004) provides perspective on the uranium contamination at SW036. The median concentration of total uranium at SW036 is 30.43 pCi/L. At station SW027, located downstream of SW036 on the SID and upstream of Pond C-2, the median concentration of total uranium is 1.62 pCi/L. At the discharge of Pond C-2, Point of Compliance (POC) GS31, the median concentration is 2.28 pCi/L. These data indicate significant attenuation of the total uranium concentration through settling of particulate uranium and/or by dilution from downstream runoff or groundwater discharge to the SID. The volume of water discharged at SW036 is less than 1 percent of the volume discharged in Woman Creek at Indiana Street. Thus, the uranium load contributed to the Woman Creek watershed by the SW036 watershed is relatively small. The median concentration of total uranium at station GS01 (POC for Woman Creek at Indiana Street) is 2.5 pCi/L, well below the surface water AL of 11 pCi/L.

As a final note, even though TCE is present in groundwater at the OLF, the following observation regarding this compound in SID surface water is provided to underscore the lack of a chronic impact:

- TCE (8 µg/L) was detected at SW036 on April 8, 1991. This compound was not detected at this station in 15 previous (except for 1 µg/L on August 8, 1990) and 7 subsequent sampling events.

4.7 Sediment

As detailed in Table 4 of Appendix B, sediments samples were analyzed for metals, radionuclides, VOCs, SVOCs, pesticides, and PCBs. As shown in Table 4-7, only a few metals were detected above background in the sediment of Woman Creek and the South Interceptor Ditch in the vicinity of the OLF. Concentrations were orders of magnitude below the RFCA ALs.

4.8 Contamination Summary and Action Determinations

Contamination of environmental media at the OLF can be summarized as follows:

- Depleted uranium "hot spots" (concentrations above wildlife refuge worker (WRW) ALs) were present in surface soil. The presence of the uranium contamination in surface soil is consistent with the instances of placing depleted uranium on the surface of the OLF. Surface soil removal and confirmation sampling have been conducted at the four uranium isotope "hot spots." A description of the soil removal and confirmation sample results are presented in Appendix C.

- PAH concentrations in surface soil are widespread, some of which exceed the WRW AL. PAH concentrations in subsurface soil are more isolated, some of which also exceed the WRW AL. It appears the source of the contamination is PAH-contaminated runoff from asphalt within the IA, and/or the burial of asphalt and street sweepings in the OLF.

- Groundwater is contaminated with uranium (at one location) and with low concentrations of TCE and PCE (more widespread arising from an upgradient source). There is no definitive contamination of groundwater by metals or other radionuclides and organics. That is, the number of detections above background and the Tier II ALs were very low for these constituents, and their concentrations were also very low relative to background and the Tier II ALs. Well 61093 is the only location where groundwater is contaminated with uranium. It appears the contamination arises from depleted uranium at the surface of the OLF. Surface water in the SID is impacted by this source of contamination from groundwater discharge and/or runoff. Low-level TCE and PCE contamination exists in groundwater at the OLF that appears to emanate from the IA. The OLF may be contributing additional, albeit minor, TCE and PCE contamination to groundwater; however, the groundwater and surface water data indicate this contamination is not migrating downgradient of the OLF and is not contaminating surface water. Therefore, the OLF is not a significant source for groundwater contamination.

- Surface water in the SID at SW036 is contaminated with uranium. Otherwise, SID (and Woman Creek) surface water immediately downgradient of the OLF has very low frequencies of analyte concentrations above the surface water ALs, which indicates the OLF does not have a significant chronic impact on these streams. It appears the depleted uranium contamination in the SID arises from the depleted uranium contamination at the surface of the OLF or from the discharge of depleted uranium-contaminated groundwater. However, uranium concentrations quickly attenuate downstream, and the uranium concentrations at the downgradient Woman Creek POCs (GS31 and GS01) are well below the surface water AL.

Given the above observations, the following action determinations have been made for the OLF:

- An action determination in accordance with ALF, Section 5.3 has been made for surface soil with uranium concentrations above the WRW ALs. These "hot spots" have been removed as approved by the CDPHE. Appendix C presents the description of the soil removal and confirmation sampling results.

- An action determination in accordance with ALF, Section 4.2 has been made for the PAH-contaminated surface and subsurface soil. The proposed accelerated action of source containment (soil cover) will be conducted in accordance with this IM/IRA (see Section 7.0).

- An action determination in accordance with ALF, Section 3.3 has been made for the uranium and chlorinated solvent groundwater contamination. The uranium-contaminated groundwater may be contributing to surface water AL exceedances at SW036 on the SID; however, it has not caused surface water ALs to be exceeded at the downgradient POCs on Woman Creek despite uncontrolled groundwater discharge from the OLF after the waste disposal operations ceased. There is no indication that PCE and TCE in groundwater at the OLF are migrating downgradient and contaminating surface water. In addition, groundwater fate and transport modeling indicates constituents in the groundwater will not reach Woman Creek above detectable levels. Monitoring (as a part of the accelerated actions) in accordance with the IMP, will evaluate contaminant concentration changes or trends.

4.9 Risk Assessment

As part of the OU 5 Phase I RFI/RI, a baseline human health risk assessment was conducted for Area of Concern 1, which is identical to the OLF area (Kaiser-Hill 1996). Although risk and health effect calculations were made for several receptors and exposure pathways, those most relevant to the future anticipated land used for RFETS are the open space user and the ecological researcher. The total estimated risk for the open space user was calculated as 6E-6 and for the ecological researcher as 1E-6.

An ecological risk assessment was conducted for several RFETS areas, including the Woman Creek Watershed, which is also contained in the OU 5 Phase I RFI/RI Report (Kaiser-Hill 1996). The methodology was developed to support risk management decisions for individual Operable Units. The approach used for the assessment is consistent with a screening-level risk assessment appropriate for sites where ecological effects have not been observed, but contaminant levels

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have been measured and can be compared with concentrations considered protective of ecological receptors.

Relevant to the OLF source area, the evaluated receptor groups and related ecological contaminants of concern (ECOCs) are as follows:

- Aquatic Life – Metals and organics in sediment;
- Aquatic feeding birds – Mercury in fish tissue and antimony in sediment;
- Small mammals- Uranium 233/234 and 238 in soils; and
- Vegetation – Metals in soils and sediments.

In summary, the assessment concluded:

- PAHs were the primary risk to aquatic life; however, no toxicity was detected in sediment toxicity tests using a *Hyalella azteca*.
- Risks from mercury to aquatic feeding birds were significant only if the birds obtained all their food from Pond C-1.
- Risks from antimony to aquatic feeding birds assumed 100 percent site use; however, the streams support a small fish population and risks were not significant if adjusted for realistic site use factors.
- Radionuclides do not present a significant risk to terrestrial receptors.
- The risk to vegetation communities is minimal because of the small source areas and the vegetation growth in contaminated sediment in littoral zones appears normal.

Based on the risk assessment information, baseline risks appear to be well within CERCLA threshold criteria. The presumptive remedy of source containment is expected to maintain or lower the baseline risks.

However, ecological impacts at the OLF will be evaluated by the Accelerated Action Ecological Screening Evaluation (AAESE). The AAESE will be applied to the Upper Woman Drainage Exposure Unit (EU) (DOE 2004, DOE 204a), which includes the OLF, to determine whether an additional accelerated action is required for the EU because of risk to ecological receptors. Because of the large size of the EU relative to the OLF, it is not anticipated the AAESE would indicate adverse ecological effects to the entire EU arising solely from the OLF. Therefore, an impact to the remedy selection for the OLF is also not anticipated.

The OLF will be evaluated as part of the Sitewide Comprehensive Risk Assessment, which is part of the RFI/RI and Corrective Measures Study/Feasibility Study (CMS/FS) that will be conducted for the Site. The need for and extent of long-term stewardship activities will be reanalyzed in the RFI/RI and CMS/FS and will be proposed, as appropriate, as part of the preferred alternative in the Proposed Plan for the Site. Institutional controls and other long-term

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stewardship requirements for Rocky Flats will ultimately be contained in the Corrective Action Decision/Record of Decision (CAD/ROD) and in any post-RFCA agreement.

Table 4-1
Surface Soil Data Summary

Analyte Group	Analyte	Total Number Samples Analyzed	Number of Samples above BG but below the AL	Number of Samples above the AL	Average Conc.	Maximum Conc.	BG Mean Plus 2SD	Wildlife Refuge Worker AL	Unit
Metal	Aluminum	51	2	0	19450	20000	16902	228000	mg/kg
Metal	Antimony	44	2	0	44.8	49.8	0.47	409	mg/kg
Metal	Barium	51	6	0	160	177	141	26400	mg/kg
Metal	Beryllium	51	15	0	1.18	1.7	0.966	921	mg/kg
Metal	Cadmium	45	2	0	3.25	4.1	1.61	962	mg/kg
Metal	Chromium	51	5	0	19.7	24.2	17.0	268	mg/kg
Metal	Cobalt	51	3	0	12.4	13.6	10.9	1550	mg/kg
Metal	Copper	51	20	0	57.8	184	18.1	40900	mg/kg
Metal	Iron	51	3	0	19667	20600	18037	307000	mg/kg
Metal	Lead	51	1	0	129	129	54.6	1000	mg/kg
Metal	Lithium	51	3	0	13.8	15.3	11.6	20400	mg/kg
Metal	Manganese	51	5	0	513	829	365	3480	mg/kg
Metal	Mercury	51	12	0	0.253	0.38	0.134	25200	mg/kg
Metal	Nickel	50	20	0	17.6	26.3	14.9	20400	mg/kg
Metal	Strontium	51	3	0	54.8	62.4	48.9	613000	mg/kg
Metal	Tin	51	2	0	18.9	30.9	2.9	613000	mg/kg
Metal	Zinc	51	10	0	119	199	73.8	307000	mg/kg
PCB	Aroclor-1254	51	12	0	1481	3900	-	12400	ug/kg
Pesticide	4,4'-DDT	51	1	0	21	21	-	100000	ug/kg
Pesticide	Dieldrin	51	1	0	34	34	-	1720	ug/kg
Pesticide	Endosulfan sulfate	51	1	0	24	24	-	4420000	ug/kg
Radionuclide	Americium-241	57	9	0	0.0447	0.0865	0.0227	76	pCi/g
Radionuclide	Plutonium-239/240	58	11	0	0.144	0.338	0.066	50	pCi/g
Radionuclide	Uranium-234	59	11	1	293	2800	2.25	300	pCi/g
Radionuclide	Uranium-235	59	9	4	84.5	670	0.0939	8	pCi/g
Radionuclide	Uranium-238	59	16	4	2620	38000	2	351	pCi/g
SVOC	2-Methylnaphthalene	48	2	0	6395	12000	-	20400000	ug/kg
SVOC	Acenaphthene	49	2	0	23300	44000	-	40800000	ug/kg
SVOC	Anthracene	49	3	0	16903	47000	-	204000000	ug/kg
SVOC	Benzo(a)anthracene	48	8	1	7215	45000	-	34900	ug/kg
SVOC	Benzo(a)pyrene	49	8	2	6765	43000	-	3490	ug/kg
SVOC	Benzo(b)fluoranthene	49	10	1	6677	49000	-	34900	ug/kg
SVOC	Benzo(k)fluoranthene	49	7	0	4008	25000	-	349000	ug/kg
SVOC	Chrysene	48	8	0	7461	46000	-	3490000	ug/kg
SVOC	Dibenz(a,h)anthracene	36	2	1	5150	9200	-	3490	ug/kg
SVOC	Dibenzofuran	49	2	0	10650	20000	-	2950000	ug/kg

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Analyte Group	Analyte	Total Number Samples Analyzed	Number of Samples above BG but below the AL	Number of Samples above the AL	Average Conc.	Maximum Conc.	BG Mean Plus 2SD	Wildlife Refuge Worker AL	Unit
SVOC	Fluoranthene	49	14	0	12551	140000	-	27200000	ug/kg
SVOC	Fluorene	49	2	0	20650	39000	-	40800000	ug/kg
SVOC	Indeno(1,2,3-cd)pyrene	38	3	0	12067	32000	-	34900	ug/kg
SVOC	Pyrene	49	14	0	10767	120000	-	22100000	ug/kg
VOC	Naphthalene	49	2	0	22000	41000	-	3090000	ug/kg
	Above the Wildlife Refuge Worker Action Level								

Note: Analytes shown are those that were detected at least once above background levels and have a Wildlife Refuge Worker Action Level. The maximum concentration is the maximum detected value, and the average concentration is the average of the data that exceed background.
BG – Background
AL - Action Level

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Table 4-2
Subsurface Soil Data Summary

Analyte Group	Analyte	Total Number Samples Analyzed	Number of Samples above BG but below the AL	Number of Samples above the AL	Average Conc.	Maximum Conc.	BG Mean Plus 2SD	Wildlife Refuge Worker AL	Unit
Metal	Antimony	51	1	0	19.5	19.5	16.97	409	mg/kg
Metal	Arsenic	62	1	0	18.9	18.9	13.14	22.2	mg/kg
Metal	Barium	62	1	0	387	387	289.38	26400	mg/kg
Metal	Cadmium	61	1	0	2.3	2.3	1.7	962	mg/kg
Metal	Chromium	62	3	0	118	165	68.27	268	mg/kg
Metal	Copper	62	11	0	779	6920	38.21	40900	mg/kg
Metal	Iron	62	2	0	64200	78900	41047	307000	mg/kg
Metal	Lead	62	12	0	105	304	24.97	1000	mg/kg
Metal	Manganese	62	3	0	1273	1540	902	3480	mg/kg
Metal	Molybdenum	60	1	0	190	190	25.61	5110	mg/kg
Metal	Nickel	62	6	0	93.6	118	62.21	20400	mg/kg
Metal	Silver	60	1	0	36	36	24.54	5110	mg/kg
Metal	Zinc	62	10	0	342	673	139.1	307000	mg/kg
PCB	Aroclor-1254	53	7	0	694	960		12400	ug/kg
PCB	Aroclor-1260	54	3	0	887	1300		12400	ug/kg
Radionuclide	Americium-241	60	7	0	0.117	0.46	0.02	76	pCi/g
Radionuclide	Plutonium-239/240	62	18	0	0.340	3.2	0.02	50	pCi/g
Radionuclide	Uranium-234	62	4	0	13.0	30	2.64	300	pCi/g
Radionuclide	Uranium-235	62	6	0	0.606	2.3	0.12	8	pCi/g
Radionuclide	Uranium-238	62	20	0	2.69	12	1.49	351	pCi/g
SVOC	2-Methylnaphthalene	54	1	0	15000	15000		20400000	ug/kg
SVOC	Acenaphthene	54	5	0	6936	31000		40800000	ug/kg
SVOC	Anthracene	54	9	0	6143	46000		204000000	ug/kg
SVOC	Benzo(a)anthracene	54	9	1	6918	48000		34900	ug/kg
SVOC	Benzo(a)pyrene	54	9	2	6243	43000		3490	ug/kg
SVOC	Benzo(b)fluoranthene	54	10	1	6431	48000		34900	ug/kg
SVOC	Benzo(k)fluoranthene	54	10	0	2545	19000		349000	ug/kg
SVOC	Butylbenzylphthalate	54	2	0	1400	1400		147000000	ug/kg
SVOC	Chrysene	54	9	0	7412	53000		3490000	ug/kg
SVOC	Dibenz(a,h)anthracene	54	1	0	700	700		3490	ug/kg
SVOC	Dibenzofuran	54	1	0	20000	20000		2950000	ug/kg
SVOC	Fluoranthene	54	13	0	15145	160000		27200000	ug/kg
SVOC	Fluorene	54	5	0	7802	35000		40800000	ug/kg
SVOC	Indeno(1,2,3-cd)pyrene	54	9	0	3369	22000		34900	ug/kg
SVOC	Pyrene	54	12	0	14952	150000		22100000	ug/kg
VOC	Acetone	126	2	0	265	280		102000000	ug/kg
VOC	Chloroform	128	1	0	19	19		19200	ug/kg
VOC	Ethylbenzene	128	1	0	66	66		4250000	ug/kg
VOC	Methylene chloride	128	2	0	82	150		2530000	ug/kg

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Analyte Group	Analyte	Total Number Samples Analyzed	Number of Samples above BG but below the AL	Number of Samples above the AL	Average Conc.	Maximum Conc.	BG Mean Plus 2SD	Wildlife Refuge Worker AL	Unit
VOC	Naphthalene	54	5	0	12914	61000		3090000	ug/kg
VOC	Tetrachloroethene	128	14	0	256	900		615000	ug/kg
VOC	Toluene	126	37	0	40	220		31300000	ug/kg
VOC	Trichloroethene	128	10	0	97.8	390		19600	ug/kg
VOC	Xylene	128	1	0	150	150		2040000	ug/kg
	Above the Wildlife Refuge Worker Action Level								

Note: Analytes shown are those that were detected at least once above background levels and have a Wildlife Refuge Worker Action Level. The maximum concentration is the maximum detected value, and the average concentration is the average of the data that exceed background.
BG – Background
AL - Action Level

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Table 4-3
Groundwater Data Summary

Analyte Group	Analyte	Total Number Samples Analyzed	Number of Samples above BG but below the Tier II AL[1]	Number of Samples above Tier II AL but below the Tier I AL	Number of Samples above Tier I AL	Average Conc.	Maximum Conc.	BG Mean Plus 2SD	Tier II AL	Tier I AL	Unit
Metal	Aluminum	201	9	0	0	2.21	4.9	0.234	36.5	3650	mg/L
Metal	Antimony*	200	6	3	0	0.0631	0.0719	0.03954	0.006	0.6	mg/L
Metal	Arsenic	202	12	0	0	0.0101	0.0197	0.00531	0.05	5	mg/L
Metal	Barium	210	67	0	0	0.241	0.647	0.153	2	200	mg/L
Metal	Beryllium	202	0	2	0	0.00615	0.007	0.00267	0.004	0.4	mg/L
Metal	Cadmium	203	1	2	0	0.0054	0.0064	0.00425	0.005	0.5	mg/L
Metal	Chromium	209	1	0	0	0.018	0.018	0.0124	0.1	10	mg/L
Metal	Copper	201	15	0	0	0.0198	0.0317	0.0139	1.3	130	mg/L
Metal	Lead	203	1	1	0	0.0505	0.087	0.0110	0.015	1.5	mg/L
Metal	Lithium	197	2	0	0	0.157	0.166	0.143	0.73	73	mg/L
Metal	Manganese	204	63	15	0	1.02	10.5	0.162	1.72	172	mg/L
Metal	Mercury	196	4	0	0	0.00044	0.0006	0.00025	0.002	0.2	mg/L
Metal	Nickel	210	24	13	0	0.152	0.654	0.0214	0.14	14	mg/L
Metal	Selenium	208	0	24	0	0.521	1.02	0.0437	0.05	5	mg/L
Metal	Silver	202	5	0	0	0.01076	0.0122	0.00708	0.183	18.3	mg/L
Metal	Strontium	201	19	0	0	1.28	1.97	0.931	21.9	2190	mg/L
Metal	Thallium	199	9	12	0	0.00645	0.0083	0.0049	0.002	0.2	mg/L
Metal	Zinc	202	5	0	0	0.294	1.03	0.0498	11	1100	mg/L
Pesticide	Dieldrin	29	0	4	0	0.183	0.24	-	0.00532	0.532	µg/L
Radionuclide	Americium-241	26	0	1	0	0.74	0.74	0.03	0.145	14.5	pCi/L
Radionuclide	Plutonium-239/240	27	2	0	0	0.022	0.033	0.01	0.151	15.1	pCi/L
Radionuclide	Radium-226	50	13	0	0	0.74	1.2	0.48	20	2000	pCi/L
Radionuclide	Strontium-90*	111	8	8	0	1.64	3.4	0.96	0.852	85.2	pCi/L

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Analyte Group	Analyte	Total Number Samples Analyzed	Number of Samples above BG but below the Tier II AL[1]	Number of Samples above Tier II AL but below the Tier I AL	Number of Samples above Tier I AL	Average Conc.	Maximum Conc.	BG Mean Plus 2SD	Tier II AL	Tier I AL	Unit
Radionuclide	Uranium-235*	188	4	1	0	1.55	1.547	1.48	1.01	101	pCi/L
Radionuclide	Uranium-238*	188	129	0	1	80.83	80.83	40.2	0.768	76.8	pCi/L
SVOC	2,4-Dimethylphenol	80	1	0	0	2	2	-	730	73000	µg/L
SVOC	2-Methylphenol	80	1	0	0	1	1	-	1830	183000	µg/L
SVOC	4-Methylphenol	80	2	0	0	6.5	10	-	183	18300	µg/L
SVOC	Acenaphthene	81	10	0	0	3.1	5	-	2190	219000	µg/L
SVOC	Anthracene	81	1	0	0	0.5	0.5	-	11000	1100000	µg/L
SVOC	bis(2-Ethylhexyl)phthalate	80	33	4	0	12.65	150	-	6	600	µg/L
SVOC	Butylbenzylphthalate	80	6	0	0	1.83	3	-	7300	730000	µg/L
SVOC	Di-n-butylphthalate	80	1	0	0	2.00	2	-	3650	365000	µg/L
SVOC	Di-n-octylphthalate	81	13	0	0	2.48	6	-	730	73000	µg/L
SVOC	Dibenzofuran	80	22	0	0	1.82	3	-	146	14600	µg/L
SVOC	Diethylphthalate	80	5	0	0	6.40	14	-	29200	2920000	µg/L
SVOC	Fluoranthene	81	9	0	0	1.89	4	-	1460	146000	µg/L
SVOC	Fluorene	81	8	0	0	2.38	4	-	1460	146000	µg/L
SVOC	Pyrene	81	8	0	0	1.60	3	-	100	110000	µg/L
VOC	1,1,1-Trichloroethane	300	22	0	0	2.76	37	-	200	20000	µg/L
VOC	1,1,2,2-Tetrachloroethane	296	0	1	0	3.00	3	-	0.426	42.6	µg/L
VOC	1,1,2-Trichloroethane	300	1	0	0	2.00	2	-	5	500	µg/L
VOC	1,1-Dichloroethane	296	9	0	0	0.95	3	-	3650	365000	µg/L
VOC	1,1-Dichloroethene	300	52	1	0	1.61	31	-	7	700	µg/L
VOC	1,2,4-Trichlorobenzene	261	1	0	0	0.70	0.7	-	70	7000	µg/L
VOC	1,2-Dichloroethene (total)	118	8	0	0	2.88	4	-	70	7000	µg/L
VOC	1,4-Dichlorobenzene	261	1	0	0	0.40	0.4	-	75	7500	µg/L

Analyte Group	Analyte	Total Number Samples Analyzed	Number of Samples above BG but below the Tier II AL[1]	Number of Samples above Tier II AL but below the Tier I AL	Number of Samples above Tier I AL	Average Conc.	Maximum Conc.	BG Mean Plus 2SD	Tier II AL	Tier I AL	Unit
VOC	4-Methyl-2-pentanone	190	1	0	0	2.00	2	-	2920	292000	µg/L
VOC	Acetone	172	26	0	0	17.09	65	-	3650	365000	µg/L
VOC	Benzene	296	3	0	0	0.47	1	-	5	500	µg/L
VOC	Carbon Disulfide	190	3	0	0	0.70	1	-	3650	365000	µg/L
VOC	Carbon Tetrachloride	300	7	0	0	1.11	2.5	-	5	500	µg/L
VOC	Chloroform	299	15	0	0	0.30	0.74	-	100	10000	µg/L
VOC	Hexachlorobutadiene	261	2	0	0	0.10	0.1	-	1.09	109	µg/L
VOC	Methylene chloride	298	50	7	0	2.62	23	-	5	500	µg/L
VOC	Naphthalene	262	12	0	0	4.26	16	-	1460	146000	µg/L
VOC	Tetrachloroethene	301	76	15	0	6.78	110	-	5	500	µg/L
VOC	Toluene	296	7	0	0	0.60	2	-	1000	100000	µg/L
VOC	Trichloroethene	301	82	16	0	5.68	140	-	5	500	µg/L
VOC	Xylene	275	2	0	0	0.79	1	-	10000	1000000	µg/L
	Above the Tier II Groundwater Action Level										

Note: Analytes shown are those that were detected at least once above background levels and have a Groundwater Action Level. The maximum concentration is the maximum detected value, and the average concentration is the average of the data that exceed background. Metals and radionuclides are dissolved concentrations. Organics are total concentrations.
*Background exceeds the AL.
BG – Background
AL - Action Level
[1] This column includes the number of samples exceeding the Tier II AL but less than BG when the BG value for an analyte exceeds the Tier II AL.

Table 4-4a
Upgradient Woman Creek Surface Water Data Summary (Total Concentrations)

Analyte Group	Analyte	Total Number Samples Analyzed	Number of Samples above BG but below the AL[1]	Number of Samples above AL	Average Conc.	Maximum Conc.	BG Mean Plus 2SD	Surface Water AL	Unit
Metal	Aluminum*	51	23	3	5.08	5.52	3.45	0.087	mg/L
Metal	Barium	52	2	0	0.136	0.136	0.12688	0.49	mg/L
Metal	Beryllium	46	0	1	0.0084	0.0084	0.00234	0.004	mg/L
Metal	Lead*	52	0	8	0.01	0.016	0.00658	0.0065	mg/L
Metal	Mercury*	49	4	1	0.0011	0.0011	0.00041	0.00001	mg/L
Metal	Nickel	49	1	0	0.0359	0.0359	0.01987	0.123	mg/L
Metal	Silver*	52	6	1	0.0079	0.0079	0.00591	0.0006	mg/L
Radionuclide	Americium-241	43	5	2	0.0809	0.162	0.02	0.15	pCi/L
Radionuclide	Plutonium-239/240	43	4	0	0.0653	0.146	0.02	0.15	pCi/L
Radionuclide	Tritium	44	0	2	1580	2170	494	500	pCi/L
Radionuclide	Uranium-234**	35	1	1	6.61	11.5	1.59	10	pCi/L
Radionuclide	Uranium-235**	34	3	0	0.35	0.43	0.19	10	pCi/L
Radionuclide	Uranium-238**	35	4	0	2.07	2.81	1.22	10	pCi/L
SVOC	Diethylphthalate	12	1	0	2	2	-	5600	µg/L
VOC	1,2-Dichloroethane	50	0	1	11	11	-	0.38	µg/L
VOC	2-Butanone	44	1	0	12	12	-	21900	µg/L
VOC	4-Methyl-2-pentanone	46	1	0	31	31	-	2920	µg/L
VOC	Acetone	47	16	0	9.75	23	-	3650	µg/L
VOC	Carbon Disulfide	46	1	0	6	6	-	3650	µg/L
VOC	Carbon Tetrachloride	50	0	1	6	6	-	0.25	µg/L
VOC	Chloroform	50	1	0	3	3	-	5.7	µg/L
VOC	Methylene chloride	49	12	9	6.95	29	-	4.7	µg/L
VOC	Tetrachloroethene	50	0	1	10	10	-	0.8	µg/L
VOC	Toluene	48	2	0	10.5	12	-	1000	µg/L
VOC	Trichloroethene	50	0	1	8	8	-	2.7	µg/L
	Above the Surface Water Action Level								

Note: Data are for surface water stations SW039, SW040, SW041, and SW506. Analytes shown are those that were detected at least once above background levels and have a Surface Water Action Level. The maximum concentration is the maximum detected value, and the average concentration is the average of the data that exceed background.
*Background exceeds the AL.
** The uranium surface water AL is for total uranium (sum of the isotopes).
BG – Background
AL - Action Level
[1] This column includes the number of samples exceeding the AL but less than BG when the BG value for an analyte exceeds the AL.

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Table 4-4b
Upgradient Woman Creek Surface Water Data Summary
(Dissolved Concentrations)

Analyte Group	Analyte	Total Number Samples Analyzed	Number of Samples above BG but below the AL[1]	Number of Samples above the AL	Average Conc.	Maximum Conc.	BG Mean Plus 2SD	Surface Water AL	Unit
Metal	Aluminum*	49	2	2	1.57	2.5	0.421	0.087	mg/L
Metal	Copper	56	1	1	0.022	0.028	0.0158	0.016	mg/L
Metal	Lead	52	0	3	0.0073	0.008	0.00459	0.0065	mg/L
Metal	Mercury*	51	0	2	0.000385	0.00044	0.00026	0.00001	mg/L
Metal	Zinc	54	4	0	0.0693	0.0757	0.0499	0.141	mg/L
Radionuclide	Uranium-234**	21	1	0	2.28	2.28	1.08	10	pCi/L
Radionuclide	Uranium-238**	21	1	0	1.44	1.44	0.82	10	pCi/L
	Above the Surface Water Action Level								

Note: Data are for surface water stations SW039, SW040, SW041, and SW506. Analytes shown are those that were detected at least once above background levels and have a Surface Water Action Level. The maximum concentration is the maximum detected value, and the average concentration is the average of the data that exceed background.
*Background exceeds the AL.
** The uranium surface water AL is for total uranium (sum of the isotopes).
BG – Background
AL - Action Level
[1] This column includes the number of samples exceeding the AL but less than BG when the BG value for an analyte exceeds the AL.

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Table 4-5a
Downgradient Woman Creek Surface Water Data Summary (Total Concentrations)

Analyte Group	Analyte	Total Number Samples Analyzed	Number of Samples above BG but below the AL[1]	Number of Samples above the AL	Average Conc.	Maximum Conc.	BG Mean Plus 2SD	Surface Water AL	Unit
Metal	Aluminum*	61	25	1	24.8	24.8	3.45	0.087	mg/L
Metal	Antimony*	58	2	2	0.0502	0.0559	0.0350	0.006	mg/L
Metal	Barium	63	1	0	0.238	0.238	0.127	0.49	mg/L
Metal	Beryllium	61	0	1	0.0044	0.0044	0.00234	0.004	mg/L
Metal	Cadmium*	57	1	1	0.0068	0.0068	0.00393	0.0015	mg/L
Metal	Copper	60	0	2	0.04305	0.0609	0.0153	0.016	mg/L
Metal	Lead*	59	0	2	0.0215	0.0248	0.00658	0.0065	mg/L
Metal	Selenium*	59	0	5	0.0118	0.02	0.00565	0.0046	mg/L
Metal	Silver*	61	5	1	0.07	0.07	0.00591	0.0006	mg/L
Metal	Zinc*	63	1	1	0.312	0.312	0.155	0.141	mg/L
Pesticide	Toxaphene	19	0	1	1	1	-	0.0002	µg/L
Radionuclide	Americium-241	59	5	4	0.112	0.38	0.02	0.15	pCi/L
Radionuclide	Plutonium-239/240	61	8	2	0.103	0.26	0.02	0.15	pCi/L
Radionuclide	Uranium-234**	43	3	0	2.41	2.9	1.59	10	pCi/L
Radionuclide	Uranium-235**	40	3	0	0.447	0.74	0.19	10	pCi/L
Radionuclide	Uranium-238**	43	2	0	1.81	2.06	1.22	10	pCi/L
SVOC	n-Nitrosodiphenylamine	19	2	0	3	5	-	5	µg/L
VOC	1,1-Dichloroethane	66	1	0	3	3	-	3650	µg/L
VOC	1,1-Dichloroethene	68	1	0	5	5	-	7	µg/L
VOC	1,2-Dichloroethane	68	0	2	8.5	14	-	0.38	µg/L
VOC	1,2-Dichloropropane	66	0	1	3	3	-	0.52	µg/L
VOC	Acetone	56	7	0	12.1	57	-	3650	µg/L
VOC	Carbon Disulfide	64	1	0	1	1	-	3650	µg/L
VOC	Carbon Tetrachloride	67	0	1	6	6	-	0.25	µg/L
VOC	Ethylbenzene	66	1	0	1	1	-	700	µg/L
VOC	Methylene chloride	66	10	6	5.78	26	-	4.7	µg/L
VOC	Styrene	66	1	0	1	1	-	100	µg/L
VOC	Tetrachloroethene	68	0	1	2	2	-	0.8	µg/L
VOC	Toluene	66	2	0	7	12	-	1000	µg/L
VOC	Trichloroethene	68	0	2	14.5	26	-	2.7	µg/L
VOC	Xylene	77	2	0	2	3	-	10000	µg/L
	Above the Surface Water Action Level								

Note: Data are for surface water stations SW032, SW033, SW10295, SW50193, and SW50293. Analytes shown are those that were detected at least once above background levels and have a Surface Water Action Level. The maximum concentration is the maximum detected value, and the average concentration is the average of the data that exceed background.
*Background exceeds the AL.
** The uranium surface water AL is for total uranium (sum of the isotopes).
BG – Background
AL - Action Level
[1] This column includes the number of samples exceeding the AL but less than BG when the BG value for an analyte exceeds the AL.

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Table 4-5b
Downgradient Woman Creek Surface Water Data Summary (Dissolved Concentrations)

Analyte Group	Analyte	Total Number Samples Analyzed	Number of Samples above BG but below the AL[1]	Number of Samples above the AL	Average Conc.	Maximum Conc.	BG Mean Plus 2SD	Surface Water AL	Unit
Metal	Aluminum*	63	3	1	0.583	0.583	0.421	0.087	mg/L
Metal	Barium	65	1	0	0.123	0.123	0.116	0.49	mg/L
Metal	Beryllium*	57	0	1	0.09	0.09	0.00504	0.004	mg/L
Metal	Cadmium*	61	0	2	0.00505	0.0051	0.00308	0.0015	mg/L
Metal	Copper	59	0	2	0.0315	0.04	0.01584	0.016	mg/L
Metal	Mercury*	57	4	3	0.000353	0.00047	0.00026	0.00001	mg/L
Metal	Selenium*	63	1	3	0.0127	0.015	0.0095	0.0046	mg/L
Metal	Silver*	63	8	1	0.0103	0.0103	0.00816	0.0006	mg/L
Metal	Zinc	66	6	0	0.0612	0.074	0.0499	0.141	mg/L
Radionuclide	Americium-241	12	0	1	0.44	0.44	0.33	0.15	pCi/L
Radionuclide	Uranium-234**	31	5	0	3.00	5.72	1.08	10	pCi/L
Radionuclide	Uranium-238**	32	6	0	2.04	4.81	0.82	10	pCi/L
	Above the Surface Water Action Level								

Note: Data are for surface water stations SW032, SW033, SW10295, SW50193, and SW50293. Analytes shown are those that were detected at least once above background levels and have a Surface Water Action Level. The maximum concentration is the maximum detected value, and the average concentration is the average of the data that exceed background.
*Background exceeds the AL.
** The uranium surface water AL is for total uranium (sum of the isotopes).
BG – Background
AL - Action Level
[1] This column includes the number of samples exceeding the AL but less than BG when the BG value for an analyte exceeds the AL.

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Table 4-6a
South Interceptor Ditch Surface Water Data Summary (Total Concentrations)

Analyte Group	Analyte	Total Number Samples Analyzed	Number of Samples above BG but below the AL[1]	Number of Samples above the AL	Average Conc.	Maximum Conc.	BG Mean Plus 2SD	Surface Water AL	Unit
Metal	Aluminum*	81	39	4	32.636	99.6	3.45	0.087	mg/L
Metal	Arsenic*	79	16	3	0.00727	0.0094	0.00525	0.000018	mg/L
Metal	Barium	81	60	1	0.189	1.47	0.127	0.49	mg/L
Metal	Beryllium	79	0	1	0.00780	0.0078	0.00234	0.004	mg/L
Metal	Cadmium*	77	2	1	0.00900	0.009	0.00393	0.0015	mg/L
Metal	Copper	80	0	2	0.075	0.122	0.0153	0.016	mg/L
Metal	Lead*	81	0	4	0.045	0.084	0.00658	0.0065	mg/L
Metal	Mercury*	74	6	1	0.00053	0.00053	0.00041	0.00001	mg/L
Metal	Nickel	75	3	0	0.059	0.105	0.0199	0.123	mg/L
Metal	Selenium*	79	0	1	0.020	0.02	0.00565	0.0046	mg/L
Metal	Silver*	80	5	6	0.009	0.0133	0.00591	0.0006	mg/L
Metal	Zinc*	79	1	2	0.431	0.448	0.155	0.141	mg/L
Radionuclide	Americium-241	53	5	2	0.204	0.936	0.02	0.15	pCi/L
Radionuclide	Plutonium-239/240	68	5	2	0.172	0.612	0.02	0.15	pCi/L
Radionuclide	Tritium	47	0	3	1563	2990	494	500	pCi/L
Radionuclide	Uranium-234**	54	45	2	5.27	13.77	1.59	10	pCi/L
Radionuclide	Uranium-235**	52	26	0	0.426	1.03	0.19	10	pCi/L
Radionuclide	Uranium-238**	54	11	30	16.9	74	1.22	10	pCi/L
SVOC	bis(2-Ethylhexyl)phthalate	23	1	2	2	3	-	1.8	µg/L
SVOC	Diethylphthalate	23	1	0	4	4	-	5600	µg/L
SVOC	n-Nitrosodiphenylamine	23	1	0	4	4	-	5	µg/L
VOC	2-Butanone	51	2	0	7.5	12	-	21900	µg/L
VOC	Acetone	52	5	0	49.54	210	-	3650	µg/L
VOC	Bromoform	59	1	0	1.9	1.9		4.3	
VOC	Chloroform	59	4	0	2.36	4	-	5.7	µg/L
VOC	Methylene chloride	59	10	3	3.08	7	-	4.7	µg/L
VOC	Toluene	59	2	0	2	3	-	1000	µg/L
VOC	Trichloroethene	59	1	1	4.5	8	-	2.7	µg/L
	Above the Surface Water Action Level								

Note: Data are for surface water stations INT. DITCH, SW036, SW038, SW129, and SW500. Analytes shown are those that were detected at least once above background levels and have a Surface Water Action Level. The maximum concentration is the maximum detected value, and the average concentration is the average of the data that exceed background.
*Background exceeds the AL.
** The uranium surface water AL is for total uranium (sum of the isotopes).
BG – Background
AL - Action Level
[1] This column includes the number of samples exceeding the AL but less than BG when the BG value for an analyte exceeds the AL.

423

Table 4-6b
South Interceptor Ditch Surface Water Data Summary
(Dissolved Concentrations)

Analyte Group	Analyte	Total Number Samples Analyzed	Number of Samples above BG but below the AL[1]	Number of Samples above the AL	Average Conc.	Maximum Conc.	BG Mean Plus 2SD	Surface Water AL	Unit
Metal	Aluminum*	51	3	1	46.9	46.9	0.421	0.087	mg/L
Metal	Arsenic*	47	7	2	0.0045	0.005	0.00382	0.000018	mg/L
Metal	Barium	53	36	0	0.145	0.178	0.116	0.49	mg/L
Metal	Beryllium*	53	1	1	0.09	0.09	0.00504	0.004	mg/L
Metal	Cadmium*	47	1	2	0.0042	0.0048	0.00308	0.0015	mg/L
Metal	Copper	51	0	1	0.101	0.101	0.0158	0.016	mg/L
Metal	Lead	52	1	2	0.0327	0.072	0.00459	0.0065	mg/L
Metal	Mercury*	48	1	3	0.0007	0.001	0.00026	0.00001	mg/L
Metal	Nickel	51	1	0	0.063	0.063	0.0186	0.123	mg/L
Metal	Zinc	51	3	2	0.298	1	0.0499	0.141	mg/L
Radionuclide	Uranium-234**	26	20	1	3.18	11.8	1.08	10	pCi/L
Radionuclide	Uranium-238**	26	15	4	7.47	25.9	0.82	10	pCi/L
	Above the Surface Water Action Level								

Note: Data are for surface water stations INT. DITCH, SW036, SW038, SW129, and SW500. Analytes shown are those that were detected at least once above background levels and have a Surface Water Action Level. The maximum concentration is the maximum detected value, and the average concentration is the average of the data that exceed background.
*Background exceeds the AL.
** The uranium surface water AL is for total uranium (sum of the isotopes).
BG – Background
AL - Action Level
[1] This column includes the number of samples exceeding the AL but less than BG when the BG value for an analyte exceeds the AL.

424

Table 4-7
Sediment Data Summary

Analyte	Total Number Samples Analyzed	Number of Samples above BG but below the AL	Number of Samples above the AL	Average Conc.	Maximum Conc.	Bkg Mean Plus 2SD	Wildlife Refuge Worker AL	Unit
Aluminum	4	1	0	17400	17400	15713	228000	mg/kg
Antimony	3	1	0	36.5	36.5	13.01	409	mg/kg
Cadmium	4	1	0	2.8	2.8	1.88	962	mg/kg
Copper	4	1	0	125	125	27.3	40900	mg/kg
Mercury	4	1	0	3.8	3.8	0.34	25200	mg/kg
Nickel	4	1	0	21.3	21.3	17.9	20400	mg/kg
Silver	4	1	0	7.7	7.7	2.28	5110	mg/kg
Zinc	4	2	0	513.5	681	104	307000	mg/kg
	Above the Wildlife Refuge Worker Action Level							

Note: Analytes shown are those that were detected at least once above background levels and have a Wildlife Refuge Worker Action Level. The maximum concentration is the maximum detected value, and the average concentration is the average of the data that exceed background.
BG – Background
AL - Action Level

425

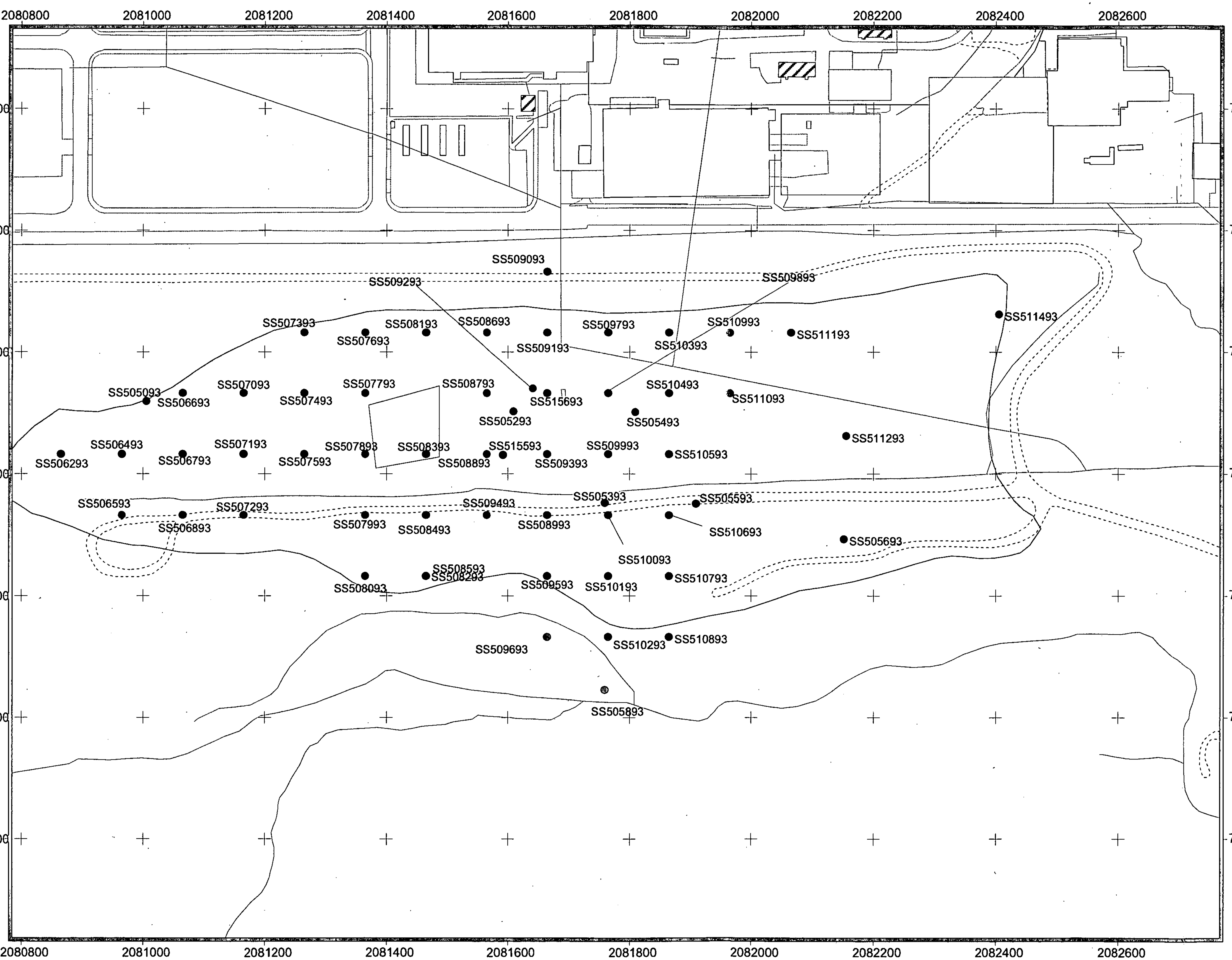

Figure 4-1
Surface Soil Sampling Locations

- Surface Soil Sampling Location
- IHSS
- Paved road
- Dirt road
- Stream
- Demolished building
- Standing building

DRAFT

N W E S

150 0 150 Feet

Scale = 1: 2000

State Plane Coordinate Projection
Colorado Central Zone
Datum: NAD 27

U.S. Department of Energy
Rocky Flats Environmental Technology Site

Prepared by: Date: June 2004

RADMS

Prepared for: KAISER+HILL COMPANY

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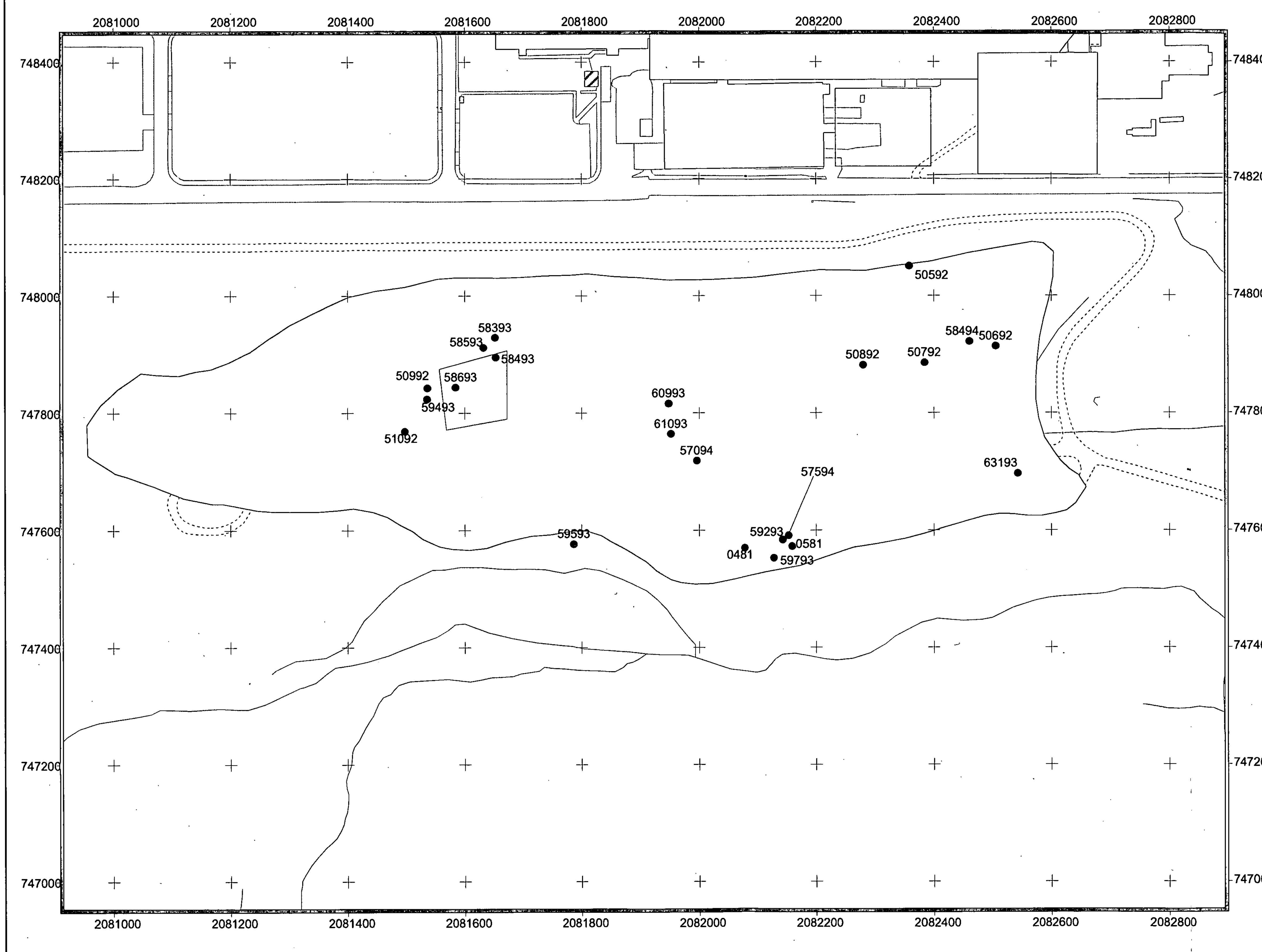

Figure 4-2
Subsurface Soil Sampling Locations

- Subsurface Soil Sampling Location
- IHSS
- Paved road
- Dirt road
- Stream
- Demolished building
- Standing building

DRAFT

N
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150 0 150 Feet

Scale = 1: 2000

State Plane Coordinate Projection
Colorado Central Zone
Datum: NAD 27

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427

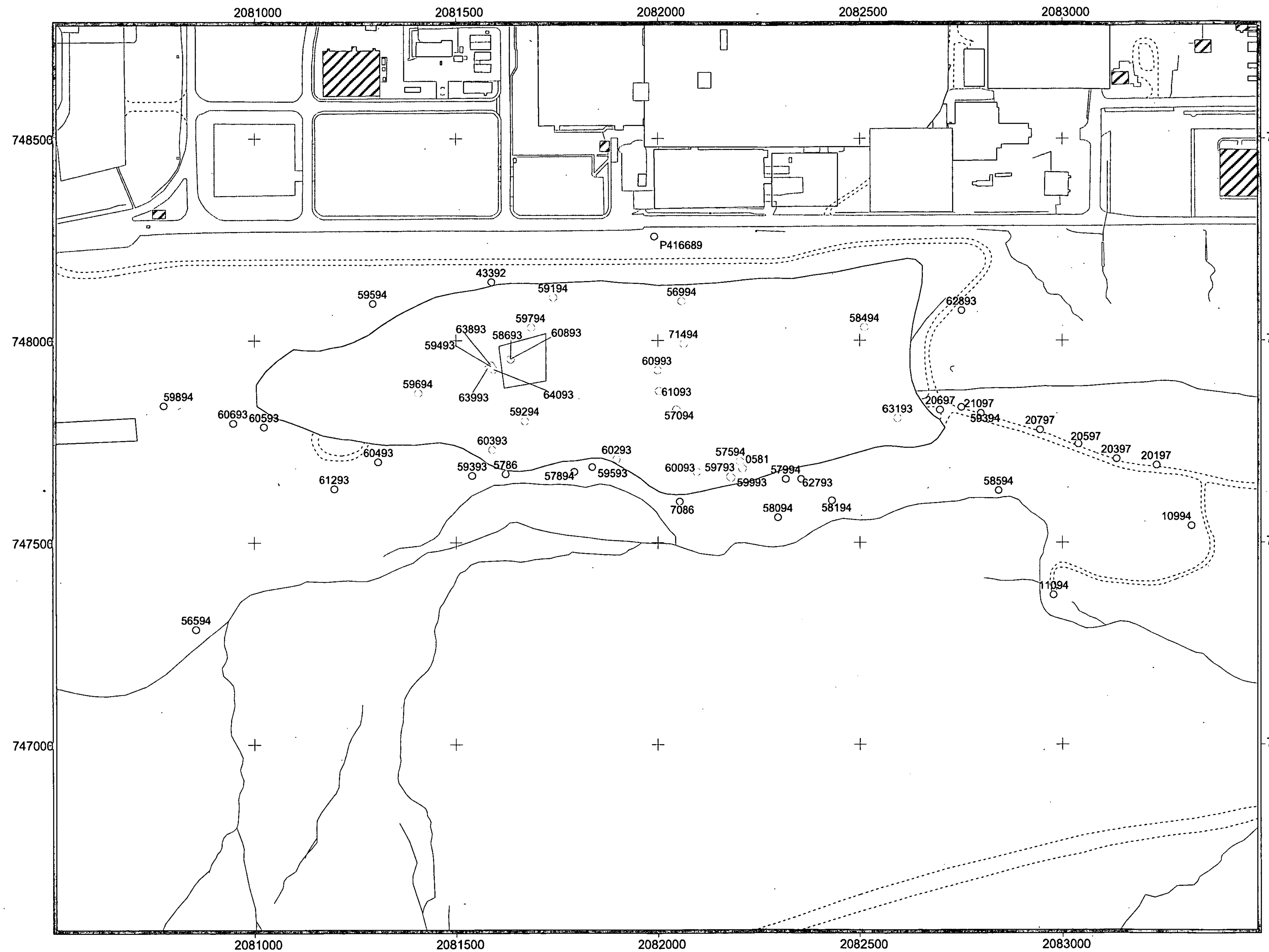

Figure 4-3
Groundwater Sampling Locations

- Groundwater Sampling Location
- IHSS
- Paved road
- Dirt road
- Stream
- Demolished building
- Standing building

DRAFT

N E S W

250 0 250 Feet

Scale = 1: 3000

State Plane Coordinate Projection
Colorado Central Zone
Datum: NAD 27

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428

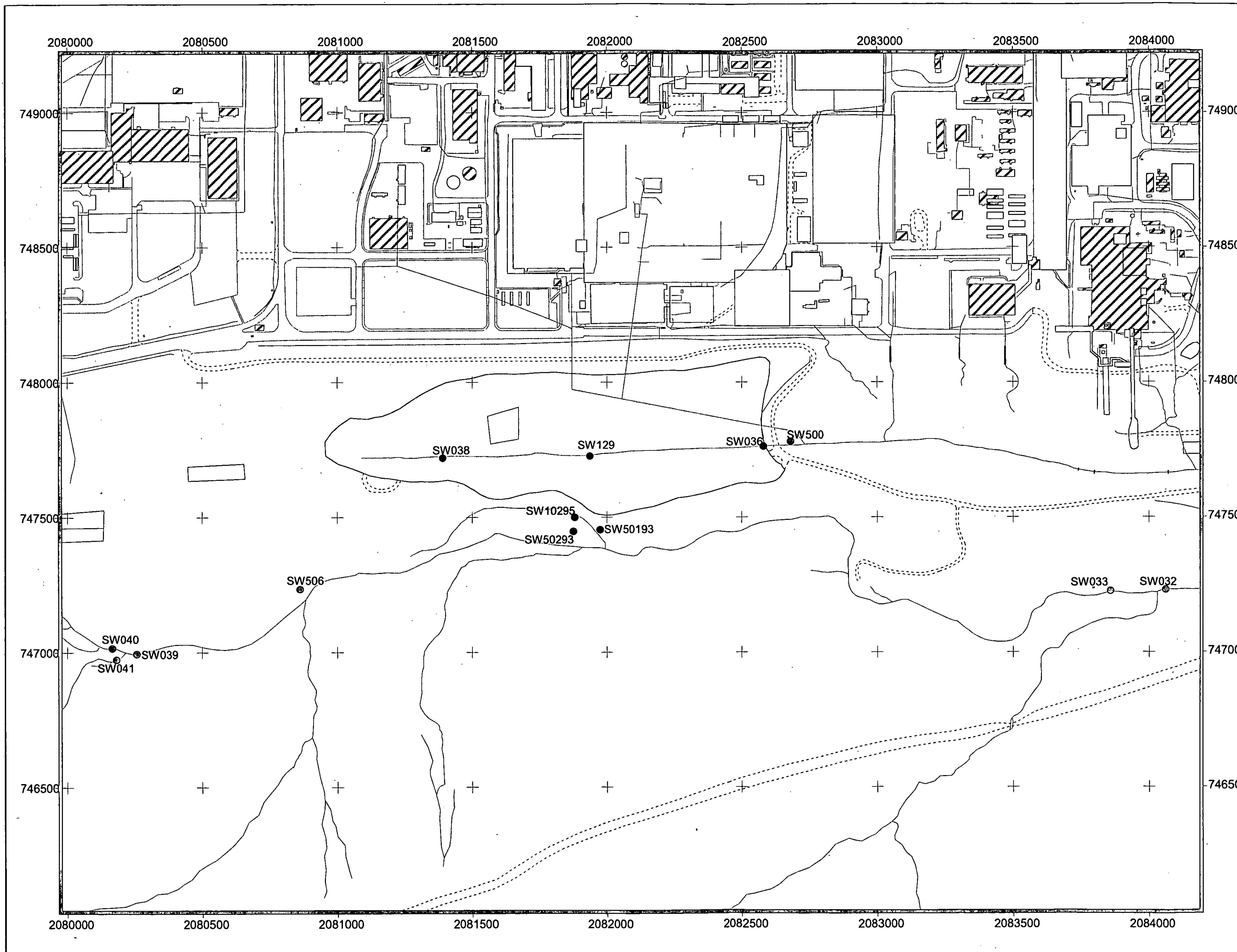

Figure 4-4
Surface Water Sampling Locations

KEY

- Surface Water Sampling Location
- IHSS
- Paved road
- Dirt road
- Stream
- Demolished building
- Standing building

DRAFT

N S E W

300 0 300 Feet

Scale = 1: 4250

State Plane Coordinate Projection
Colorado Central Zone
Datum: NAD 27

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429

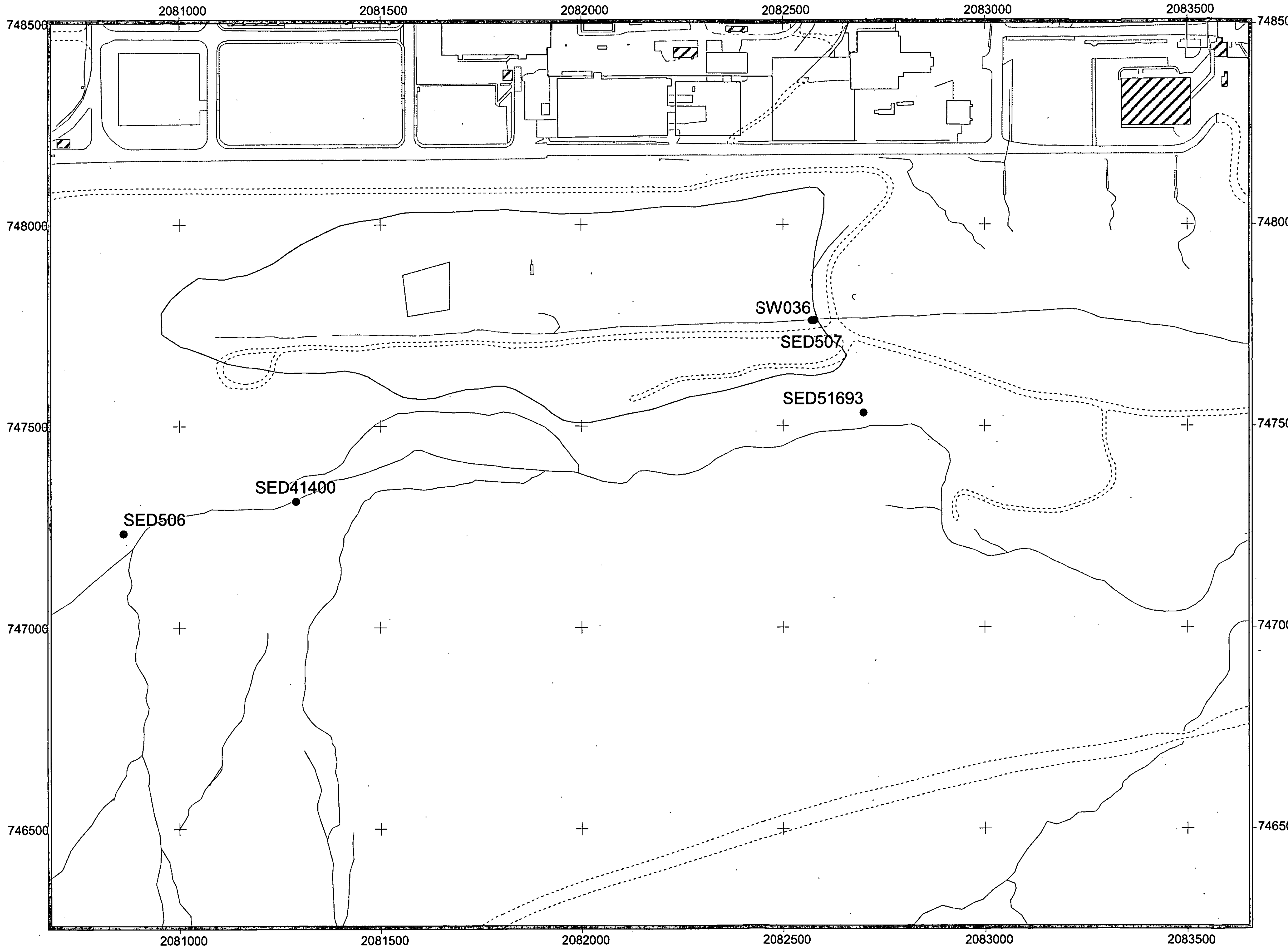

Figure 4-5
Sediment Locations
Original Landfill Area

KEY

- Sediment Location
- Paved road
- Dirt road
- Stream
- Demolished building
- Standing building
- IHSS

DRAFT

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150 0 150 300 Feet

Scale = 1: 5000

State Plane Coordinate Projection
Colorado Central Zone
Datum: NAD 27

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Date: June 2004

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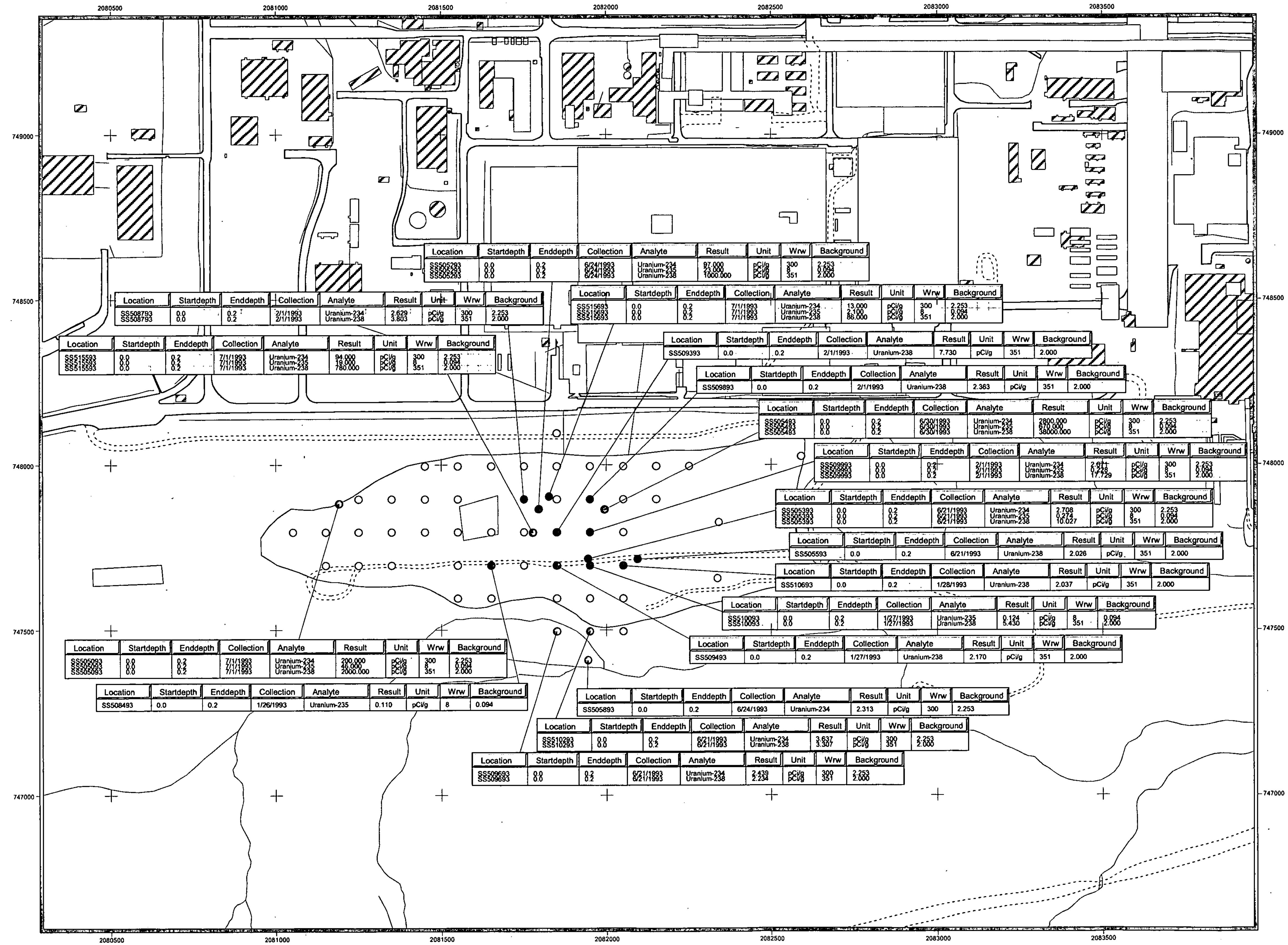

Location	Startdepth	Enddepth	Collection	Analyte	Result	Unit	Wrw	Background
SS505293	0.0	0.2	6/24/1993	Uranium-234	97.000	pCi/g	300	2.253
SS505293	0.0	0.2	6/24/1993	Uranium-235	23.000	pCi/g	8	0.094
SS505293	0.0	0.2	6/24/1993	Uranium-238	1000.000	pCi/g	351	2.000
SS508793	0.0	0.2	2/1/1993	Uranium-234	2.629	pCi/g	300	2.253
SS508793	0.0	0.2	2/1/1993	Uranium-238	3.803	pCi/g	351	2.000
SS515693	0.0	0.2	7/1/1993	Uranium-234	13.000	pCi/g	300	2.253
SS515693	0.0	0.2	7/1/1993	Uranium-235	2.100	pCi/g	8	0.094
SS515693	0.0	0.2	7/1/1993	Uranium-238	86.000	pCi/g	351	2.000
SS515593	0.0	0.2	7/1/1993	Uranium-234	94.000	pCi/g	300	2.253
SS515593	0.0	0.2	7/1/1993	Uranium-235	19.000	pCi/g	8	0.094
SS515593	0.0	0.2	7/1/1993	Uranium-238	780.000	pCi/g	351	2.000
SS509393	0.0	0.2	2/1/1993	Uranium-238	7.730	pCi/g	351	2.000
SS509893	0.0	0.2	2/1/1993	Uranium-238	2.363	pCi/g	351	2.000
SS505493	0.0	0.2	6/30/1993	Uranium-234	2800.000	pCi/g	300	2.253
SS505493	0.0	0.2	6/30/1993	Uranium-235	670.000	pCi/g	8	0.094
SS505493	0.0	0.2	6/30/1993	Uranium-238	38000.000	pCi/g	351	2.000
SS509993	0.0	0.2	2/1/1993	Uranium-234	[illegible]	pCi/g	300	2.253
SS509993	0.0	0.2	2/1/1993	Uranium-235	0.228	pCi/g	8	0.094
SS509993	0.0	0.2	2/1/1993	Uranium-238	17.729	pCi/g	351	2.000
SS505393	0.0	0.2	6/21/1993	Uranium-234	2.708	pCi/g	300	2.253
SS505393	0.0	0.2	6/21/1993	Uranium-235	0.274	pCi/g	8	0.094
SS505393	0.0	0.2	6/21/1993	Uranium-238	10.027	pCi/g	351	2.000
SS505593	0.0	0.2	6/21/1993	Uranium-238	2.026	pCi/g	351	2.000
SS510693	0.0	0.2	1/28/1993	Uranium-238	2.037	pCi/g	351	2.000
SS510093	0.0	0.2	1/27/1993	Uranium-235	0.124	pCi/g	8	0.094
SS510093	0.0	0.2	1/27/1993	Uranium-238	5.430	pCi/g	351	2.000
SS509493	0.0	0.2	1/27/1993	Uranium-238	2.170	pCi/g	351	2.000
SS505093	0.0	0.2	7/1/1993	Uranium-234	200.000	pCi/g	300	2.253
SS505093	0.0	0.2	7/1/1993	Uranium-235	46.000	pCi/g	8	0.094
SS505093	0.0	0.2	7/1/1993	Uranium-238	2000.000	pCi/g	351	2.000
SS508493	0.0	0.2	1/26/1993	Uranium-235	0.110	pCi/g	8	0.094
SS505893	0.0	0.2	6/24/1993	Uranium-234	2.313	pCi/g	300	2.253
SS510293	0.0	0.2	6/21/1993	Uranium-234	3.637	pCi/g	300	2.253
SS510293	0.0	0.2	6/21/1993	Uranium-238	3.307	pCi/g	351	2.000
SS509693	0.0	0.2	6/21/1993	Uranium-234	2.439	pCi/g	300	2.253
SS509693	0.0	0.2	6/21/1993	Uranium-238	2.234	pCi/g	351	2.000

Figure 4-6
Uranium Concentrations Above Background in Surface Soil

KEY

- Concentration Greater Than Wildlife Refuge Worker Action Level
- Concentration Greater Than Background
- Concentration Less Than Background
- Dirt Road
- Stream
- IHSS
- Paved Road

Structure
- Demolished
- Standing

All isotope concentrations are shown when any one of the isotope concentrations exceeds background.

DRAFT

N
W E
S

200 0 200 Feet

Scale = 1:3700

State Plane Coordinate Projection
Colorado Central Zone
Datum: NAD 27

U.S. Department of Energy
Rocky Flats Environmental Technology Site

Prepared by:

RADMS

10.06.04

Prepared for:

KAISER•HILL COMPANY

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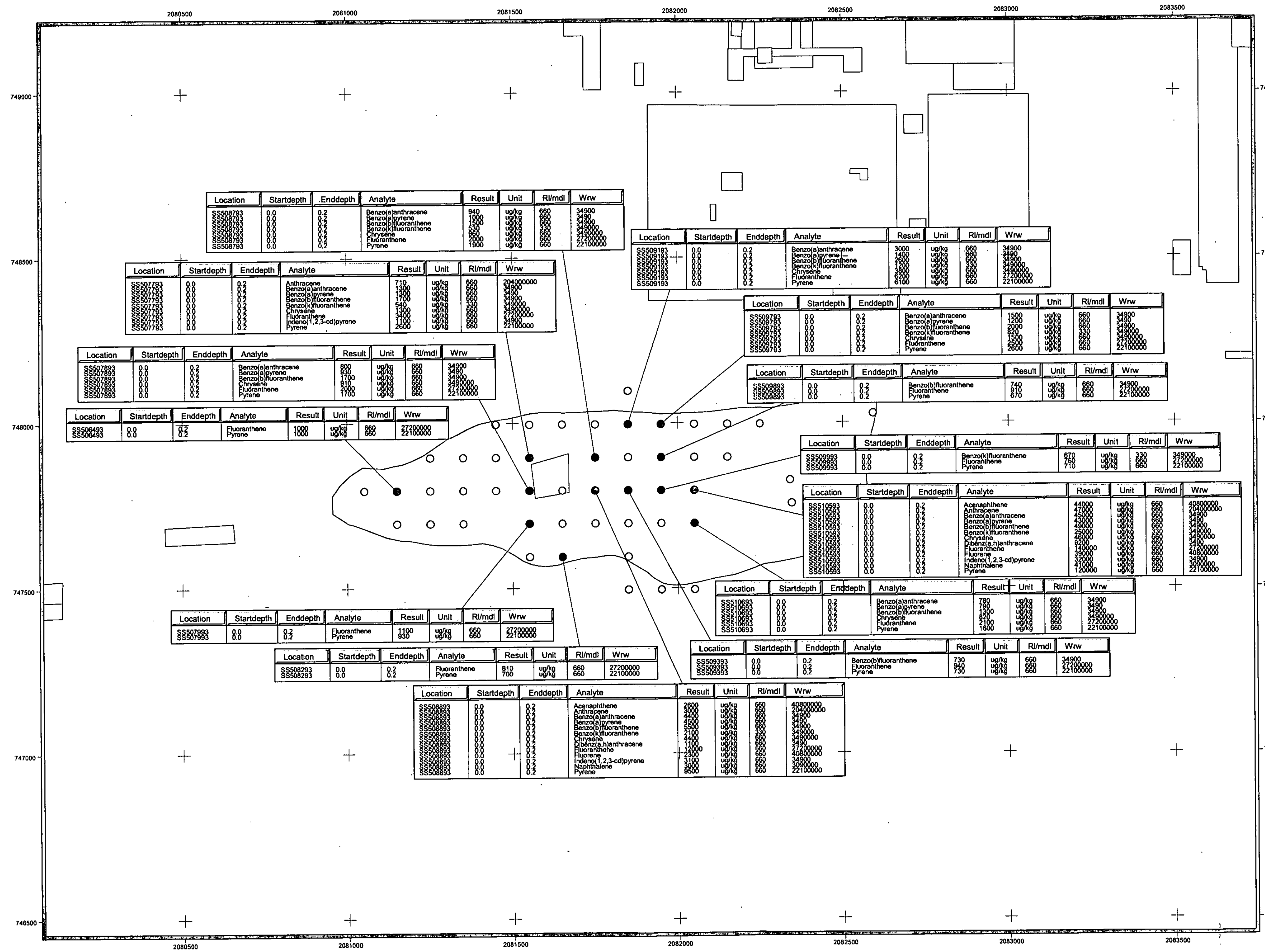
431

Figure 4-7
Polynuclear Aromatic Hydrocarbon Concentrations Above Background in Surface Soil



KEY

- Concentration Greater Than Wildlife Refuge Worker Action Level
- Concentration Greater Than MDL/RL
- Concentration Less Than MDL/RL
- Dirt Road
- Stream
- IHSS
- Paved Road

Structure

- Demolished
- Standing

DRAFT

N
W E
S

250 0 250 Feet

Scale = 1:3700

State Plane Coordinate Projection
Colorado Central Zone
Datum: NAD 27

U.S. Department of Energy
Rocky Flats Environmental Technology Site

Prepared by:

RADMS

Date: 10.06.04

Prepared for:

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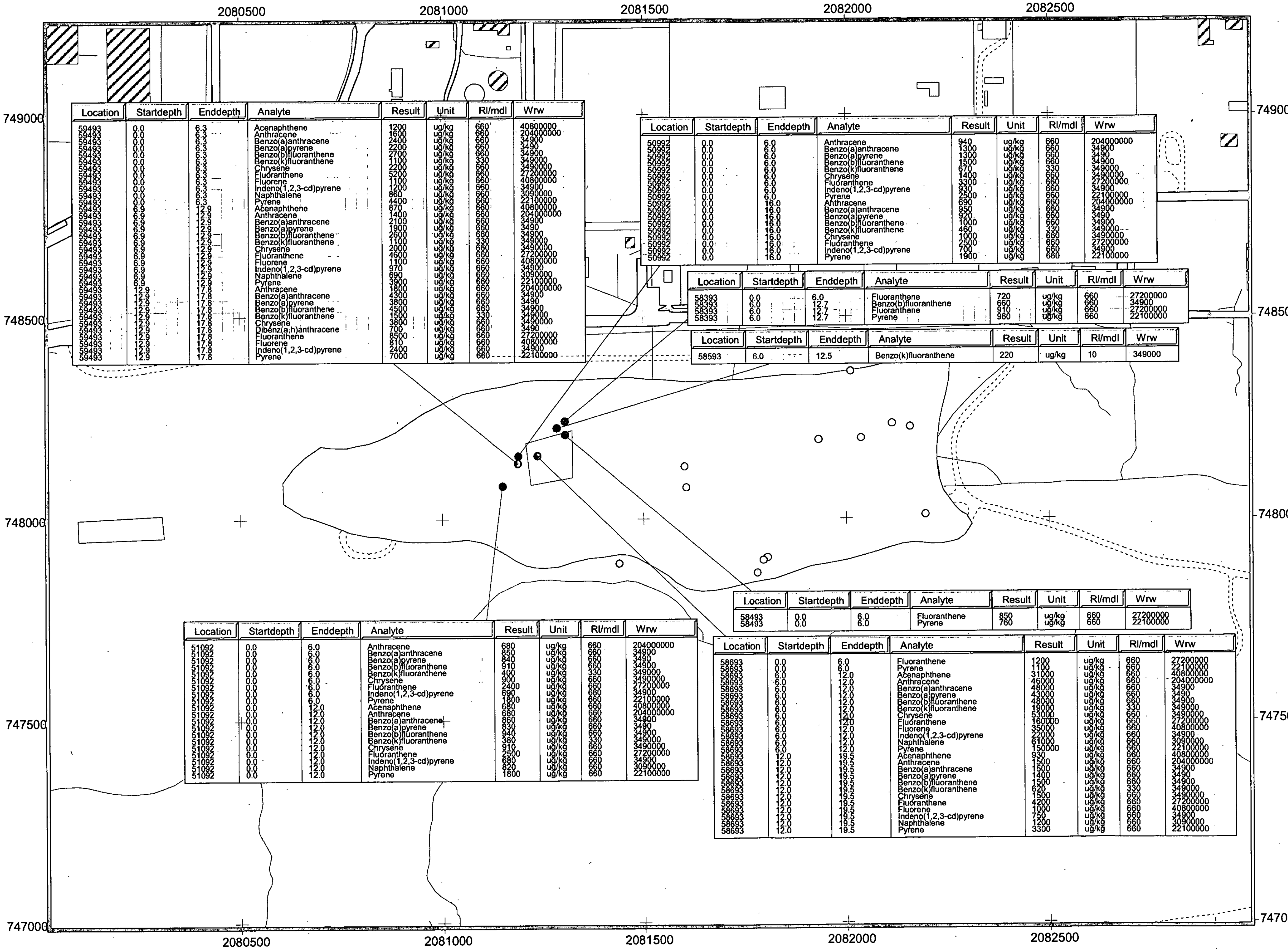
Figure 4-8
Polynuclear Aromatic Hydrocarbon Concentrations Above Background in Subsurface Soil



Location	Startdepth	Enddepth	Analyte	Result	Unit	Rl/mdl	Wrw
59493	0.0	6.3	Acenaphthene	1200	ug/kg	660	40800000
59493	0.0	6.3	Anthracene	1600	ug/kg	660	204000000
59493	0.0	6.3	Benzo(a)anthracene	2400	ug/kg	660	34900
59493	0.0	6.3	Benzo(a)pyrene	2200	ug/kg	660	3490
59493	0.0	6.3	Benzo(b)fluoranthene	2700	ug/kg	660	34900
59493	0.0	6.3	Benzo(k)fluoranthene	1100	ug/kg	330	349000
59493	0.0	6.3	Chrysene	2200	ug/kg	660	3490000
59493	0.0	6.3	Fluoranthene	5200	ug/kg	660	27200000
59493	0.0	6.3	Fluorene	1100	ug/kg	660	40800000
59493	0.0	6.3	Indeno(1,2,3-cd)pyrene	1200	ug/kg	660	34900
59493	0.0	6.3	Naphthalene	860	ug/kg	660	3090000
59493	0.0	6.3	Pyrene	4400	ug/kg	660	22100000
59493	6.9	12.9	Acenaphthene	870	ug/kg	660	40800000
59493	6.9	12.9	Anthracene	1400	ug/kg	660	204000000
59493	6.9	12.9	Benzo(a)anthracene	2100	ug/kg	660	34900
59493	6.9	12.9	Benzo(a)pyrene	1900	ug/kg	660	3490
59493	6.9	12.9	Benzo(b)fluoranthene	2600	ug/kg	660	34900
59493	6.9	12.9	Benzo(k)fluoranthene	1100	ug/kg	330	349000
59493	6.9	12.9	Chrysene	2000	ug/kg	660	3490000
59493	6.9	12.9	Fluoranthene	4600	ug/kg	660	27200000
59493	6.9	12.9	Fluorene	1100	ug/kg	660	40800000
59493	6.9	12.9	Indeno(1,2,3-cd)pyrene	970	ug/kg	660	34900
59493	6.9	12.9	Naphthalene	690	ug/kg	660	3090000
59493	6.9	12.9	Pyrene	3900	ug/kg	660	22100000
59493	12.9	17.8	Anthracene	1800	ug/kg	660	204000000
59493	12.9	17.8	Benzo(a)anthracene	4300	ug/kg	660	34900
59493	12.9	17.8	Benzo(a)pyrene	3800	ug/kg	660	3490
59493	12.9	17.8	Benzo(b)fluoranthene	4500	ug/kg	660	34900
59493	12.9	17.8	Benzo(k)fluoranthene	1500	ug/kg	330	349000
59493	12.9	17.8	Chrysene	3800	ug/kg	660	3490000
59493	12.9	17.8	Dibenz(a,h)anthracene	700	ug/kg	660	3490
59493	12.9	17.8	Fluoranthene	8500	ug/kg	660	27200000
59493	12.9	17.8	Fluorene	810	ug/kg	660	40800000
59493	12.9	17.8	Indeno(1,2,3-cd)pyrene	2400	ug/kg	660	34900
59493	12.9	17.8	Pyrene	7000	ug/kg	660	22100000

Location	Startdepth	Enddepth	Analyte	Result	Unit	Rl/mdl	Wrw
50992	0.0	6.0	Anthracene	940	ug/kg	660	204000000
50992	0.0	6.0	Benzo(a)anthracene	1300	ug/kg	660	34900
50992	0.0	6.0	Benzo(a)pyrene	1300	ug/kg	660	3490
50992	0.0	6.0	Benzo(b)fluoranthene	1500	ug/kg	660	34900
50992	0.0	6.0	Benzo(k)fluoranthene	670	ug/kg	330	349000
50992	0.0	6.0	Chrysene	1400	ug/kg	660	3490000
50992	0.0	6.0	Fluoranthene	3300	ug/kg	660	27200000
50992	0.0	6.0	Indeno(1,2,3-cd)pyrene	930	ug/kg	660	34900
50992	0.0	6.0	Pyrene	2500	ug/kg	660	22100000
50992	0.0	16.0	Anthracene	690	ug/kg	660	204000000
50992	0.0	16.0	Benzo(a)anthracene	950	ug/kg	660	34900
50992	0.0	16.0	Benzo(a)pyrene	920	ug/kg	660	3490
50992	0.0	16.0	Benzo(b)fluoranthene	1000	ug/kg	660	34900
50992	0.0	16.0	Benzo(k)fluoranthene	460	ug/kg	330	349000
50992	0.0	16.0	Chrysene	1000	ug/kg	660	3490000
50992	0.0	16.0	Fluoranthene	2500	ug/kg	660	27200000
50992	0.0	16.0	Indeno(1,2,3-cd)pyrene	700	ug/kg	660	34900
50992	0.0	16.0	Pyrene	1900	ug/kg	660	22100000

Location	Startdepth	Enddepth	Analyte	Result	Unit	Rl/mdl	Wrw
58393	0.0	6.0	Fluoranthene	720	ug/kg	660	27200000
58393	6.0	12.7	Benzo(b)fluoranthene	660	ug/kg	660	34900
58393	6.0	12.7	Fluoranthene	910	ug/kg	660	27200000
58393	6.0	12.7	Pyrene	960	ug/kg	660	22100000

Location	Startdepth	Enddepth	Analyte	Result	Unit	Rl/mdl	Wrw
58593	6.0	12.5	Benzo(k)fluoranthene	220	ug/kg	10	349000

Location	Startdepth	Enddepth	Analyte	Result	Unit	Rl/mdl	Wrw
58493	0.0	6.0	Fluoranthene	850	ug/kg	660	27200000
58493	0.0	6.0	Pyrene	760	ug/kg	660	22100000

Location	Startdepth	Enddepth	Analyte	Result	Unit	Rl/mdl	Wrw
51092	0.0	6.0	Anthracene	680	ug/kg	660	204000000
51092	0.0	6.0	Benzo(a)anthracene	850	ug/kg	660	34900
51092	0.0	6.0	Benzo(a)pyrene	840	ug/kg	660	3490
51092	0.0	6.0	Benzo(b)fluoranthene	910	ug/kg	660	34900
51092	0.0	6.0	Benzo(k)fluoranthene	400	ug/kg	330	349000
51092	0.0	6.0	Chrysene	900	ug/kg	660	3490000
51092	0.0	6.0	Fluoranthene	2400	ug/kg	660	27200000
51092	0.0	6.0	Indeno(1,2,3-cd)pyrene	690	ug/kg	660	34900
51092	0.0	6.0	Pyrene	1800	ug/kg	660	22100000
51092	0.0	12.0	Acenaphthene	680	ug/kg	660	40800000
51092	0.0	12.0	Anthracene	680	ug/kg	660	204000000
51092	0.0	12.0	Benzo(a)anthracene	860	ug/kg	660	34900
51092	0.0	12.0	Benzo(a)pyrene	830	ug/kg	660	3490
51092	0.0	12.0	Benzo(b)fluoranthene	940	ug/kg	660	34900
51092	0.0	12.0	Benzo(k)fluoranthene	380	ug/kg	330	349000
51092	0.0	12.0	Chrysene	910	ug/kg	660	3490000
51092	0.0	12.0	Fluoranthene	2500	ug/kg	660	27200000
51092	0.0	12.0	Indeno(1,2,3-cd)pyrene	680	ug/kg	660	34900
51092	0.0	12.0	Naphthalene	820	ug/kg	660	3090000
51092	0.0	12.0	Pyrene	1800	ug/kg	660	22100000

Location	Startdepth	Enddepth	Analyte	Result	Unit	Rl/mdl	Wrw
58693	0.0	6.0	Fluoranthene	1200	ug/kg	660	27200000
58693	0.0	6.0	Pyrene	1100	ug/kg	660	22100000
58693	6.0	12.0	Acenaphthene	31000	ug/kg	660	40800000
58693	6.0	12.0	Anthracene	46000	ug/kg	660	204000000
58693	6.0	12.0	Benzo(a)anthracene	48000	ug/kg	660	34900
58693	6.0	12.0	Benzo(a)pyrene	43000	ug/kg	660	3490
58693	6.0	12.0	Benzo(b)fluoranthene	48000	ug/kg	660	34900
58693	6.0	12.0	Benzo(k)fluoranthene	19000	ug/kg	330	349000
58693	6.0	12.0	Chrysene	53000	ug/kg	660	3490000
58693	6.0	12.0	Fluoranthene	160000	ug/kg	660	27200000
58693	6.0	12.0	Fluorene	35000	ug/kg	660	40800000
58693	6.0	12.0	Indeno(1,2,3-cd)pyrene	22000	ug/kg	660	34900
58693	6.0	12.0	Naphthalene	61000	ug/kg	660	3090000
58693	6.0	12.0	Pyrene	150000	ug/kg	660	22100000
58693	12.0	19.5	Acenaphthene	930	ug/kg	660	40800000
58693	12.0	19.5	Anthracene	1500	ug/kg	660	204000000
58693	12.0	19.5	Benzo(a)anthracene	1500	ug/kg	660	34900
58693	12.0	19.5	Benzo(a)pyrene	1400	ug/kg	660	3490
58693	12.0	19.5	Benzo(b)fluoranthene	1500	ug/kg	660	34900
58693	12.0	19.5	Benzo(k)fluoranthene	620	ug/kg	330	349000
58693	12.0	19.5	Chrysene	1500	ug/kg	660	3490000
58693	12.0	19.5	Fluoranthene	4200	ug/kg	660	27200000
58693	12.0	19.5	Fluorene	1000	ug/kg	660	40800000
58693	12.0	19.5	Indeno(1,2,3-cd)pyrene	750	ug/kg	660	34900
58693	12.0	19.5	Naphthalene	1200	ug/kg	660	3090000
58693	12.0	19.5	Pyrene	3300	ug/kg	660	22100000

KEY

- Concentration Greater Than Wildlife Refuge Worker Action Level
- Concentration Greater Than MDL/RL
- Concentration Less Than MDL/RL
- Dirt Road
- Stream
- IHSS
- Paved Road

Structure

- Demolished
- Standing

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N
W E
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150 0 150 Feet

Scale = 1:3000

State Plane Coordinate Projection
Colorado Central Zone
Datum: NAD 27

U.S. Department of Energy
Rocky Flats Environmental Technology Site

Prepared by: 07.13.04

RADMS

Prepared for:

KAISER•HILL
COMPANY

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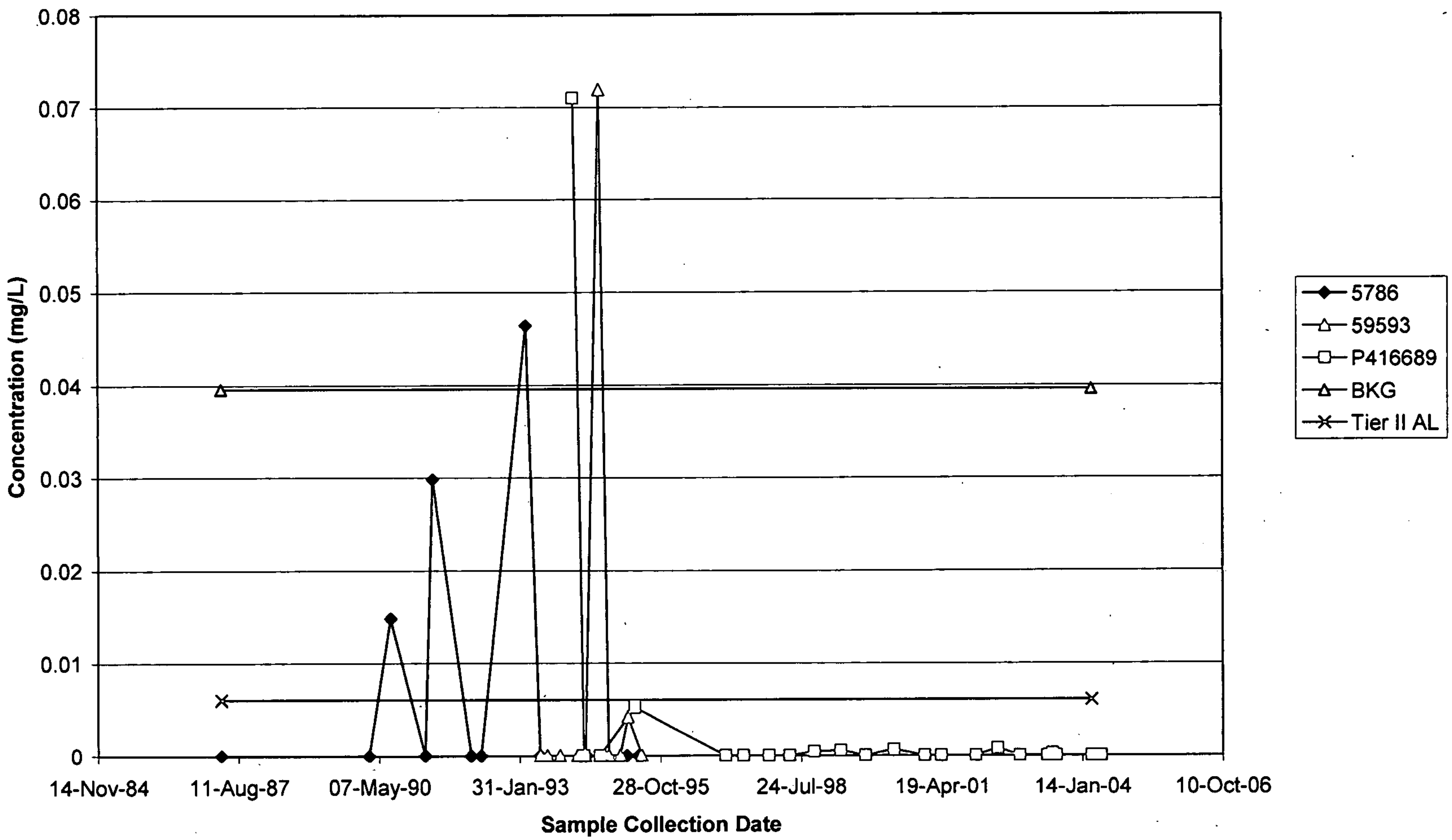
433

434

Figure 4-9 Dissolved Antimony in Groundwater



425

Figure 4-10 Dissolved Beryllium in Groundwater

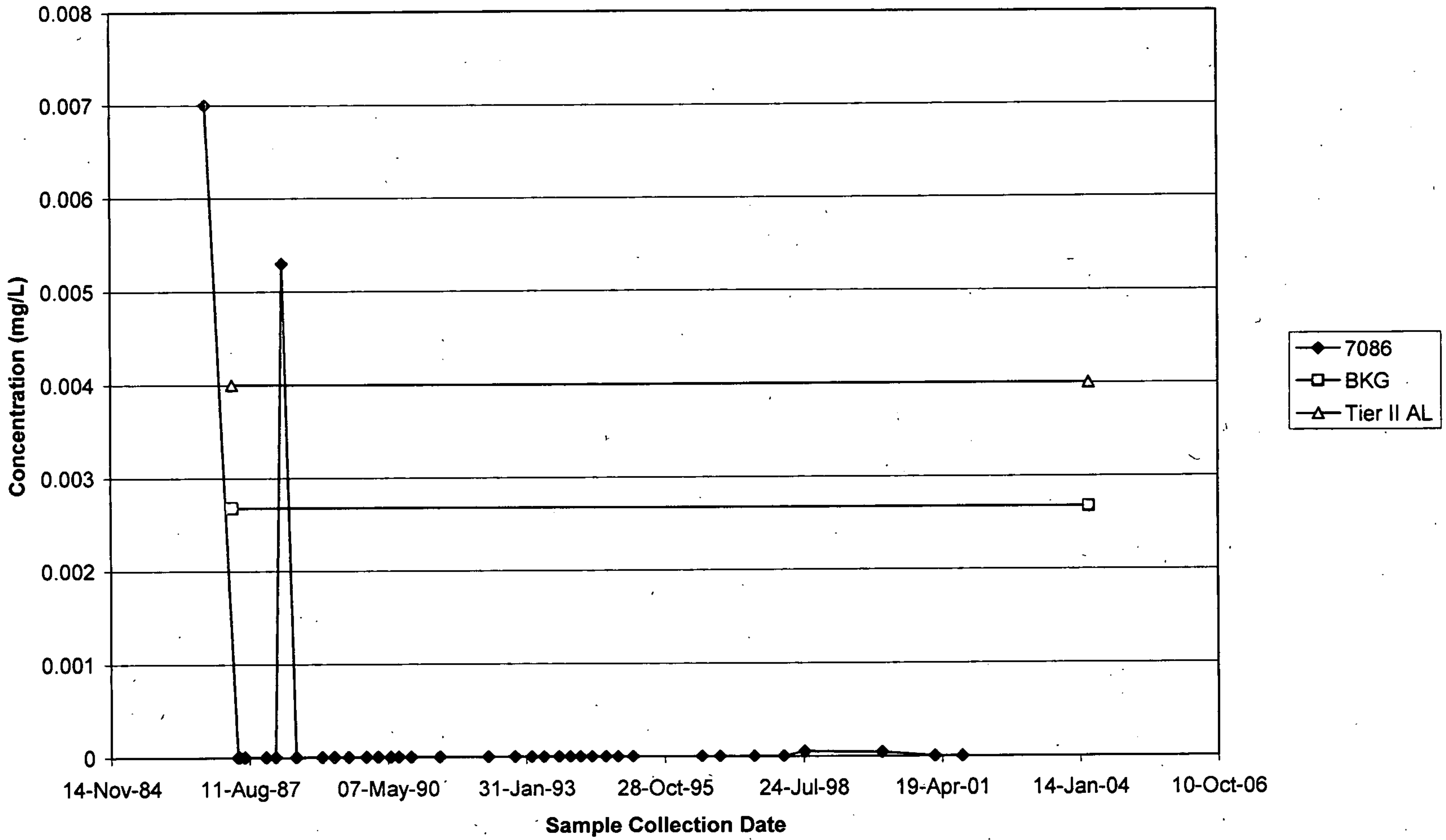
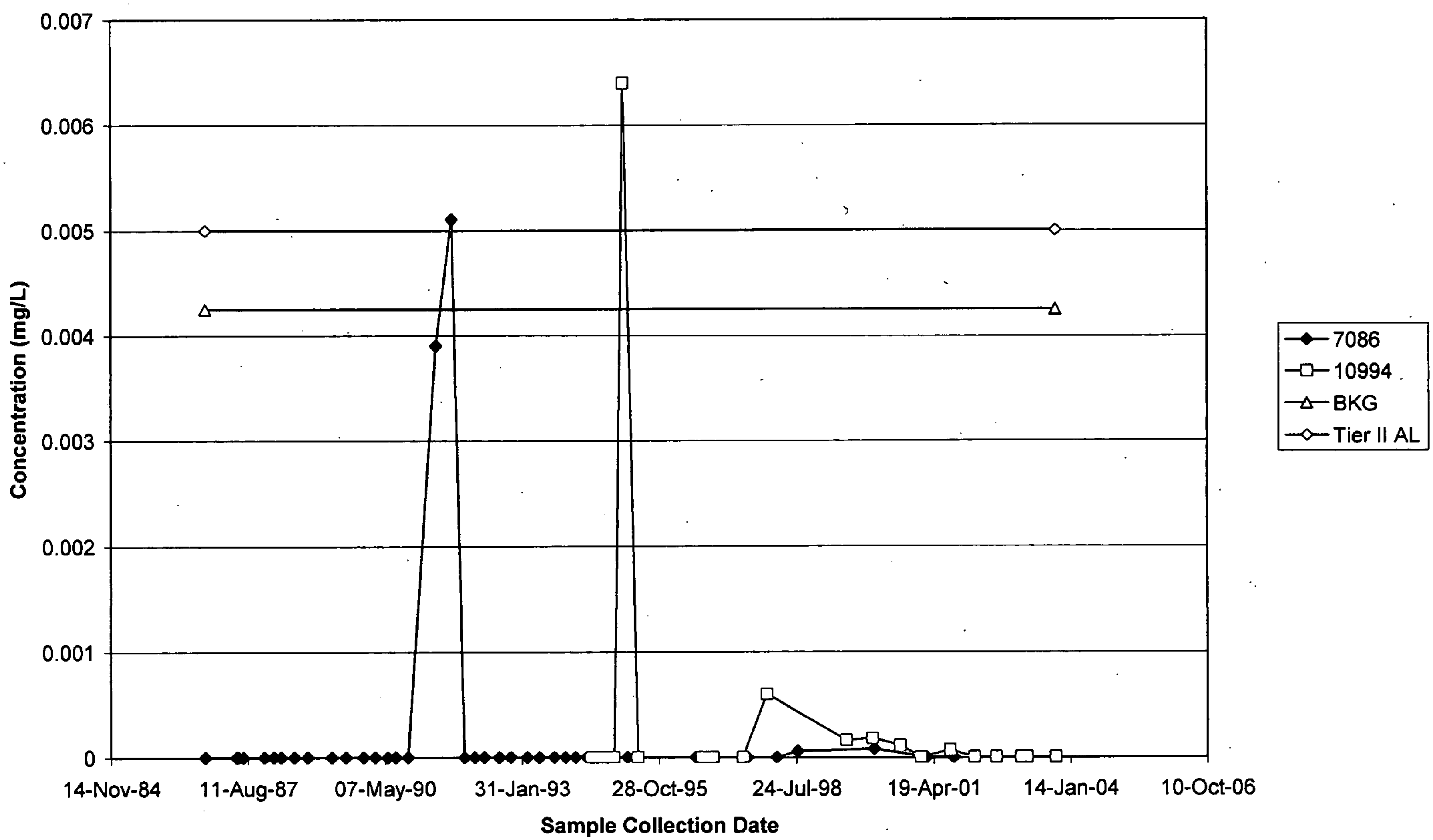


Figure 4-11 Dissolved Cadmium in Groundwater



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4377

Figure 4-12 Dissolved Lead in Groundwater

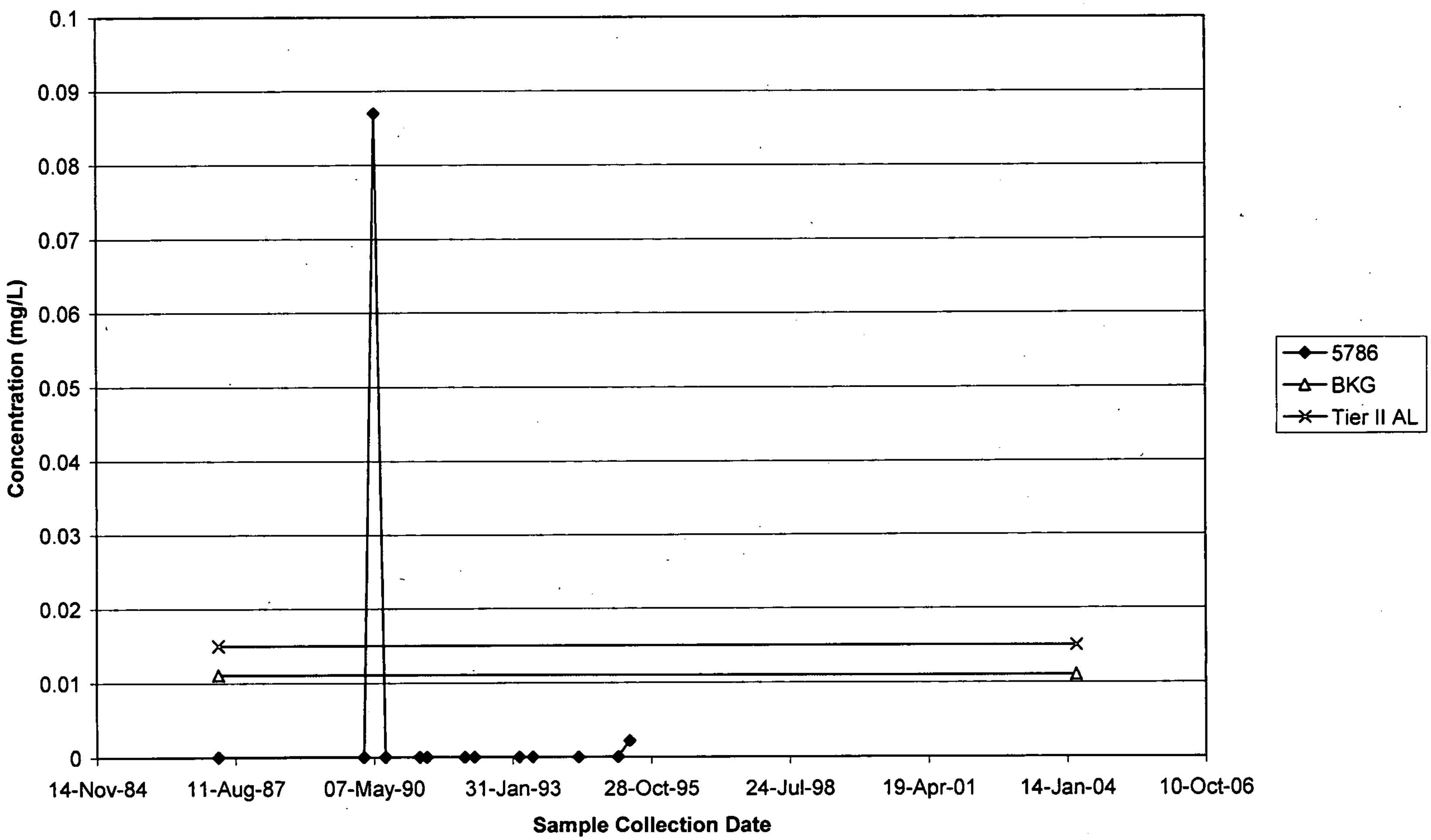

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Figure 4-13 Dissolved Manganese in Groundwater

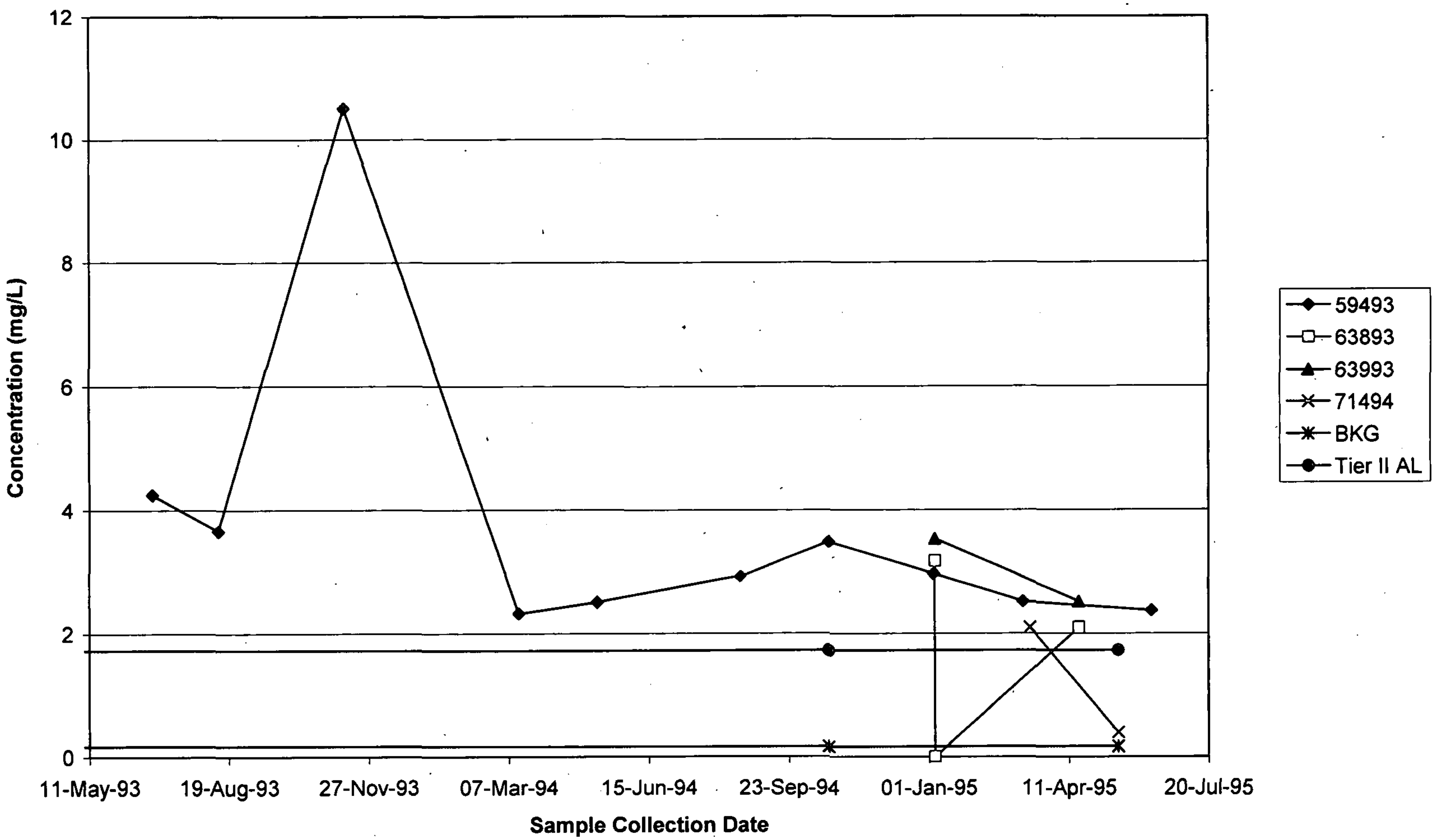

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Figure 4-14 Dissolved Nickel in Groundwater

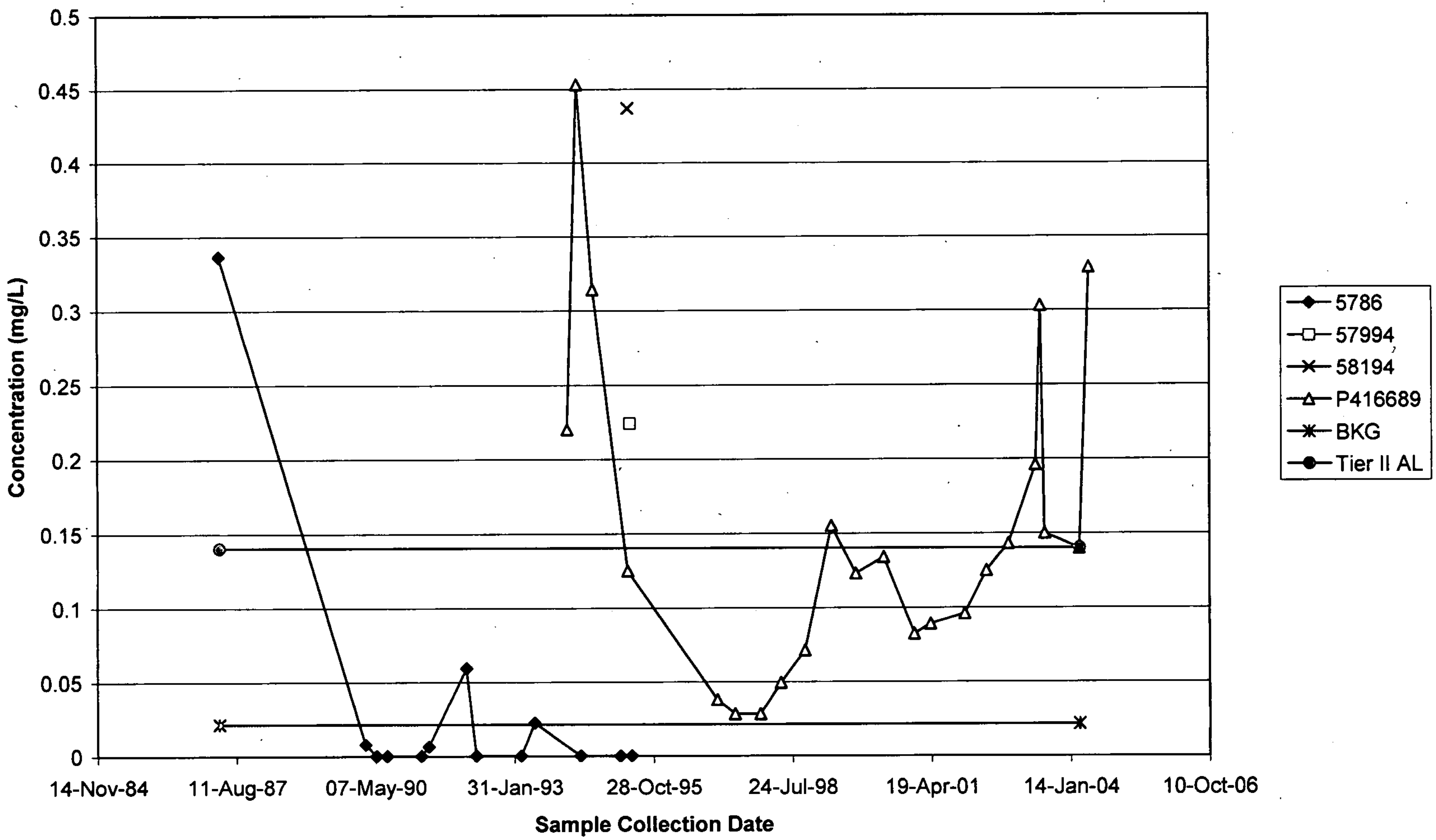

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Figure 4-15 Dissolved Selenium in Groundwater

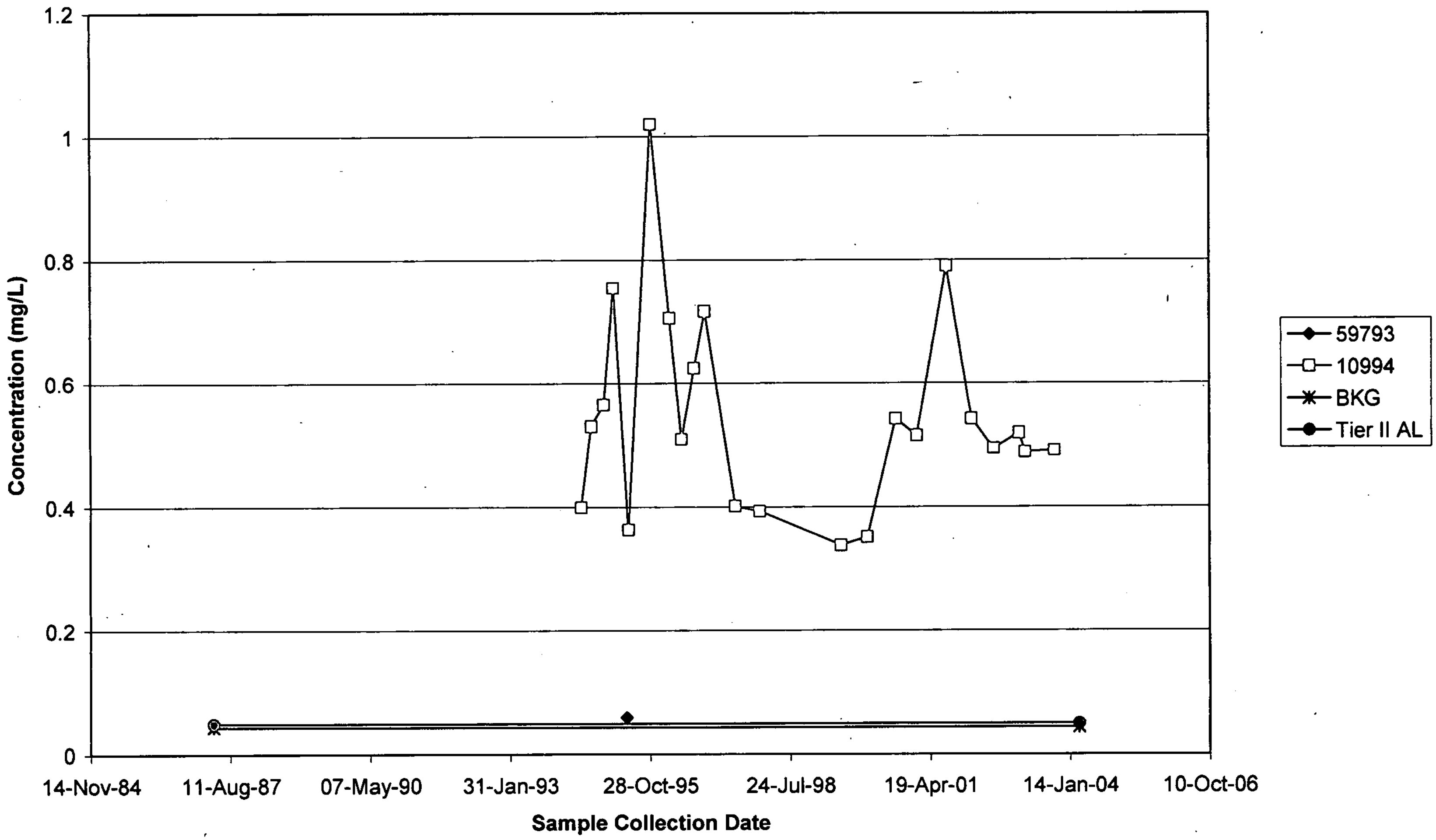

Figure 4-16 Dissolved Thallium in Groundwater

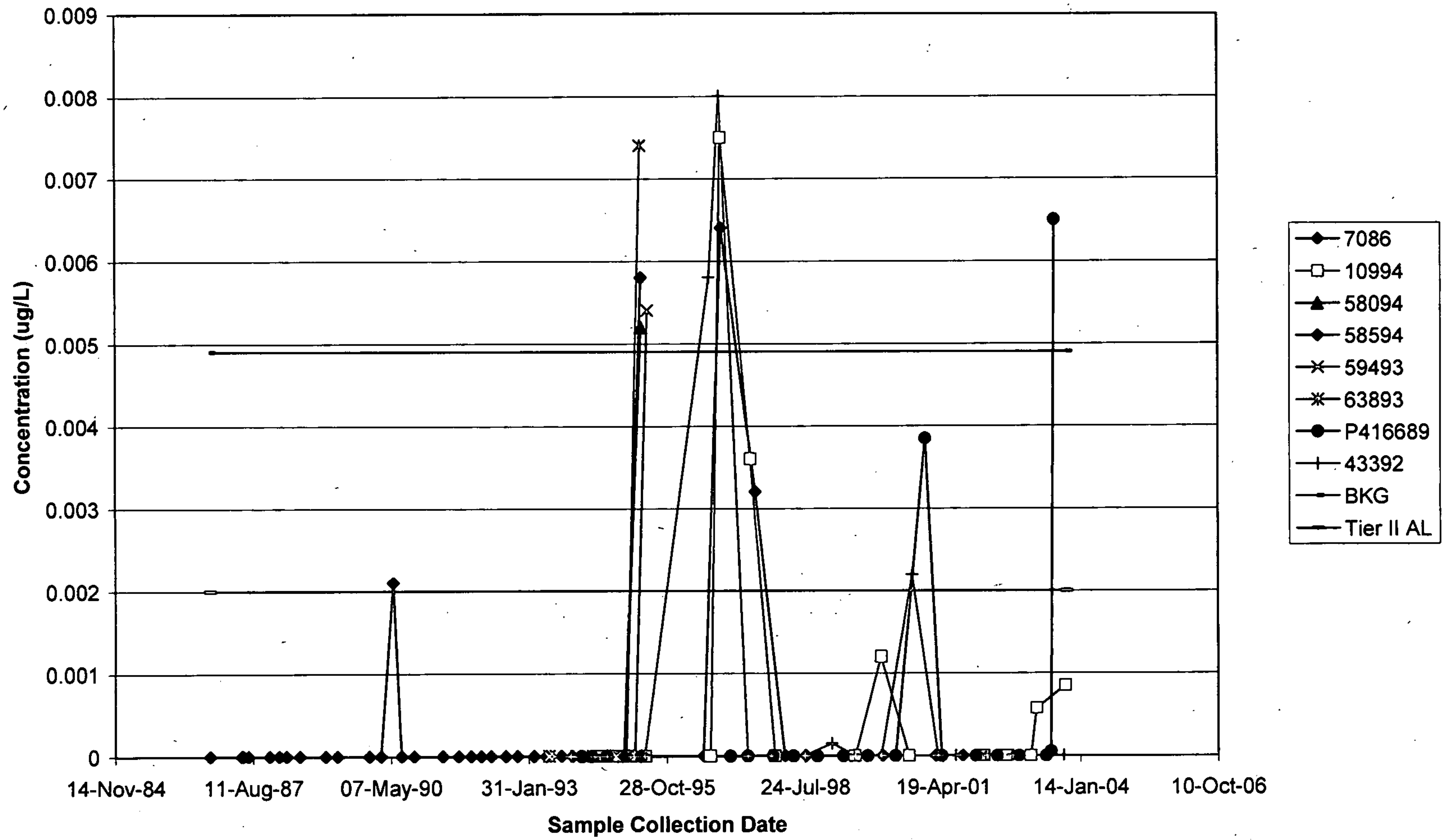

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Figure 4-17 Dissolved Strontium-90 in Groundwater

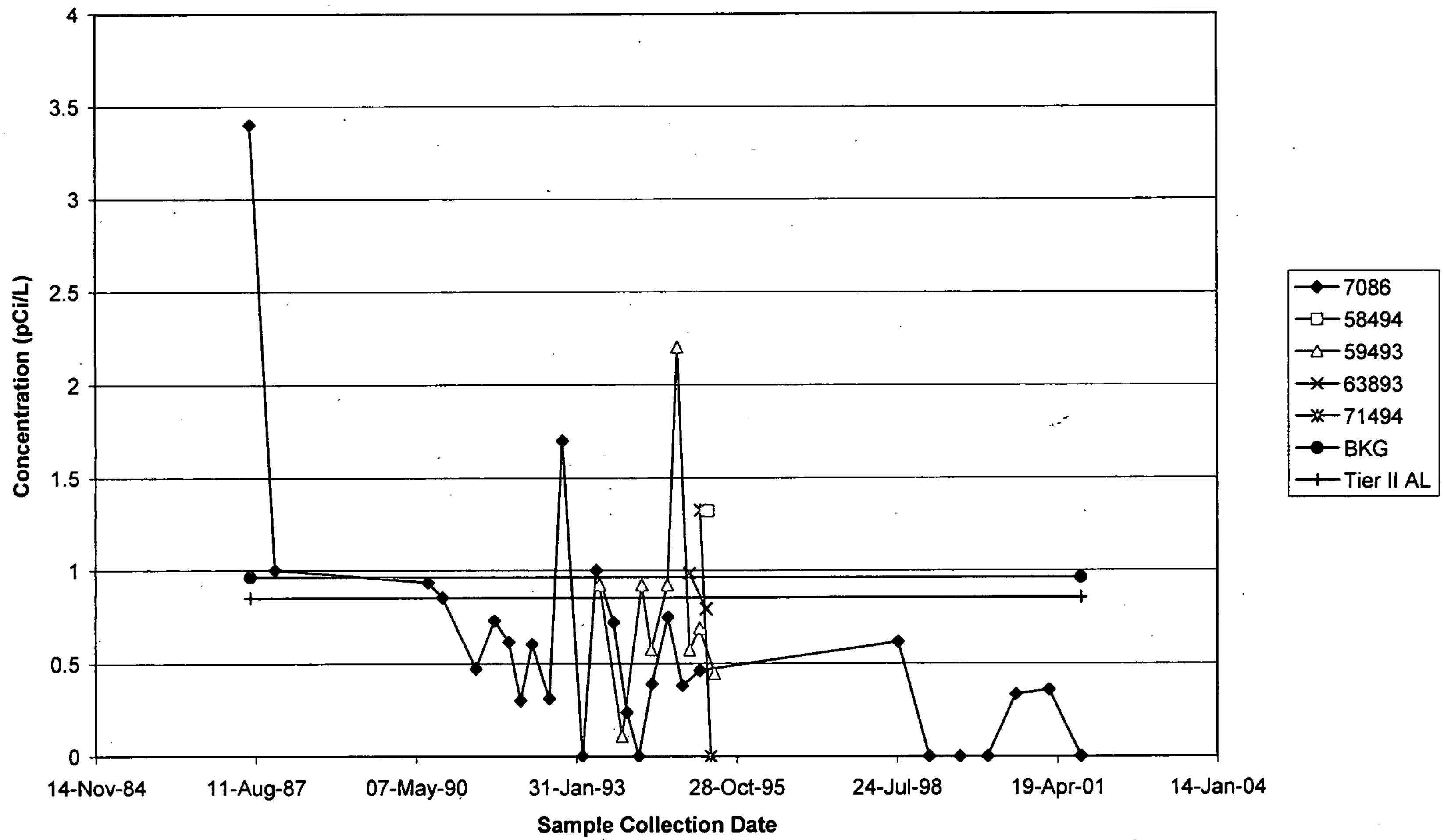

Figure 4-18 Dissolved Uranium Concentrations and Isotopic Activity Ratios in Groundwater at Well 61093

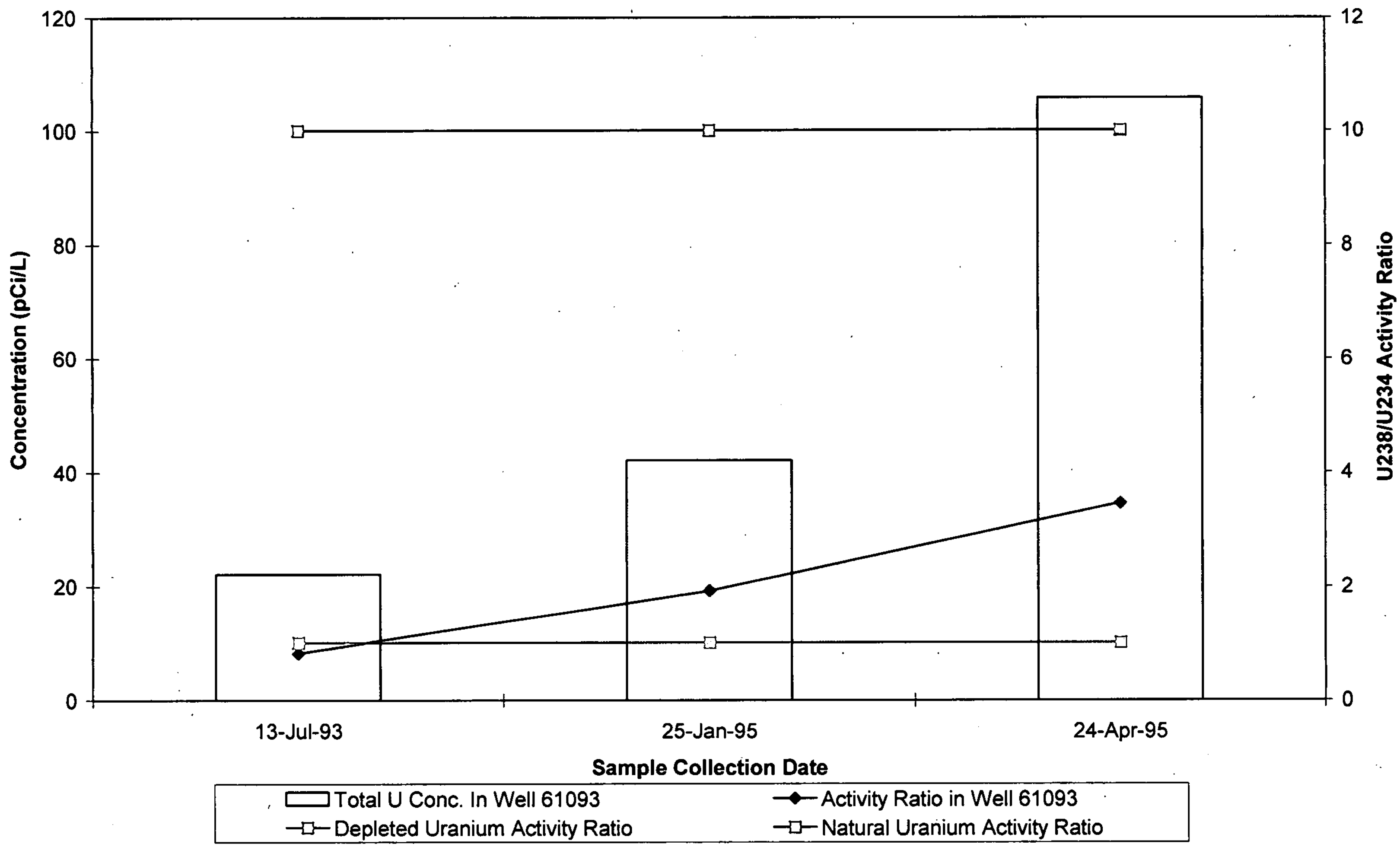

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Figure 4-19 Dissolved Uranium Concentrations and Isotopic Mass Ratios in Groundwater at Well 61093

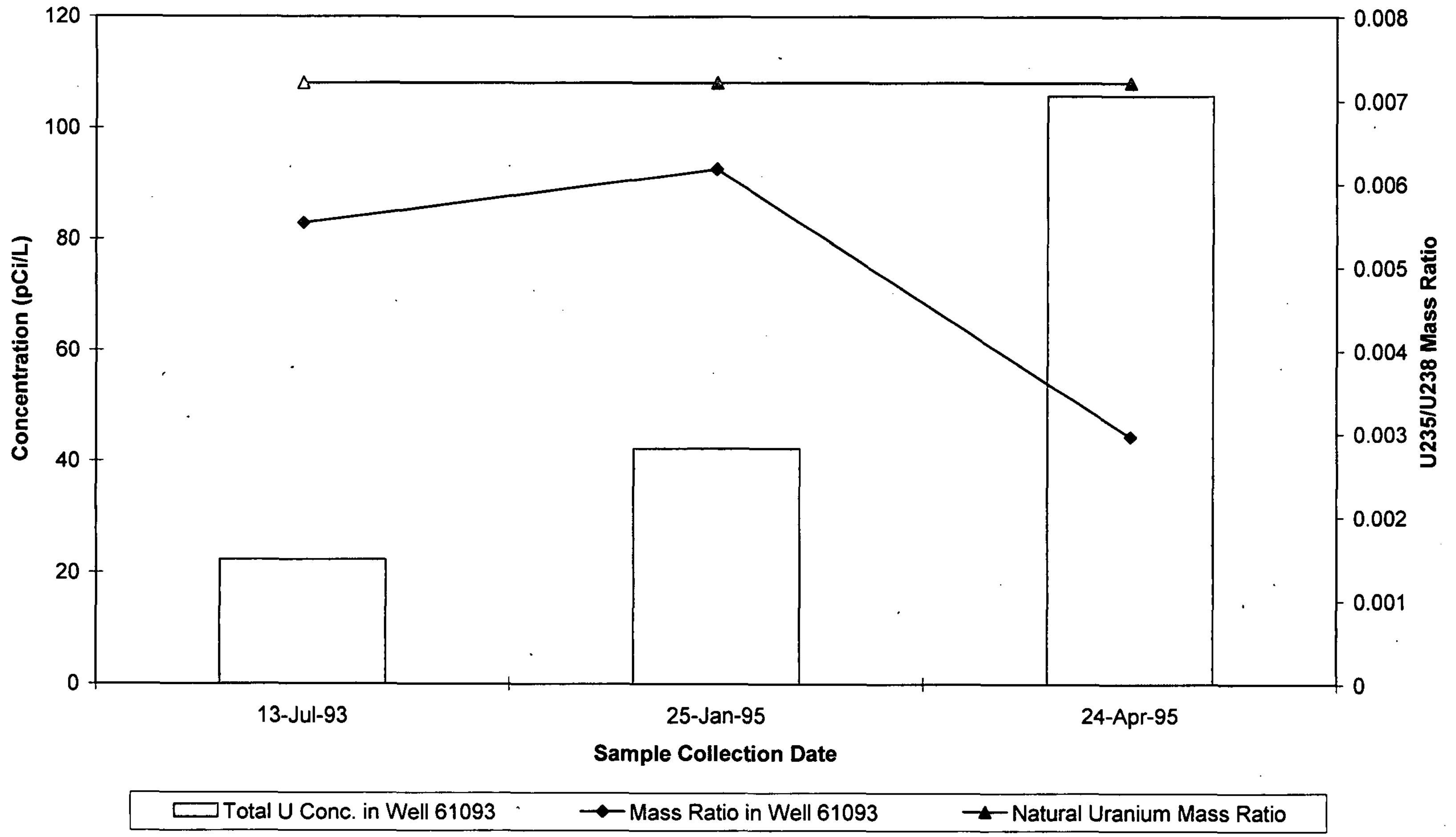

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Figure 4-20 Total Uranium Concentrations and Isotopic Mass Ratios in Groundwater Measured by ICP MS

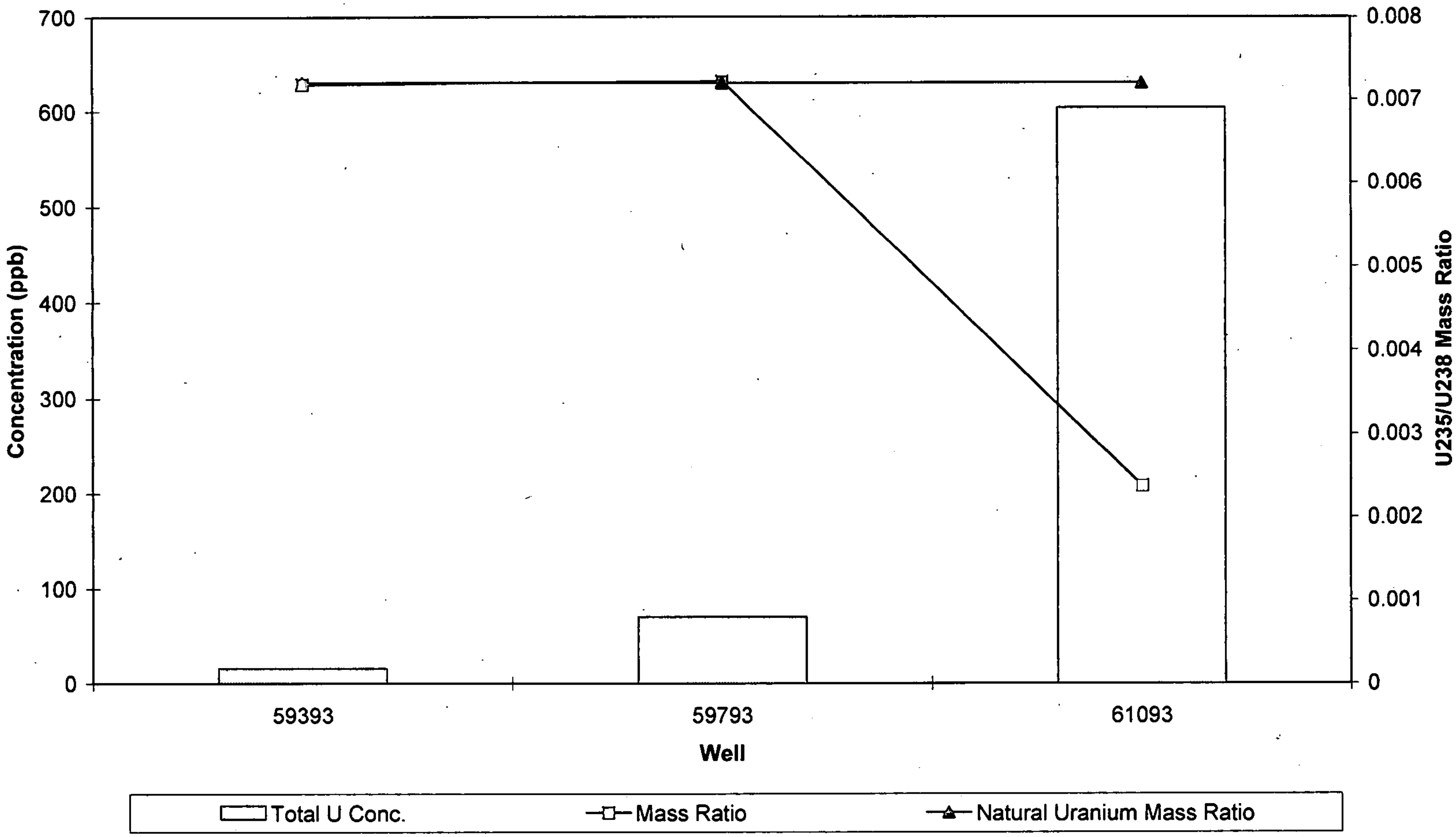

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Figure 4-21 Dieldrin in Groundwater

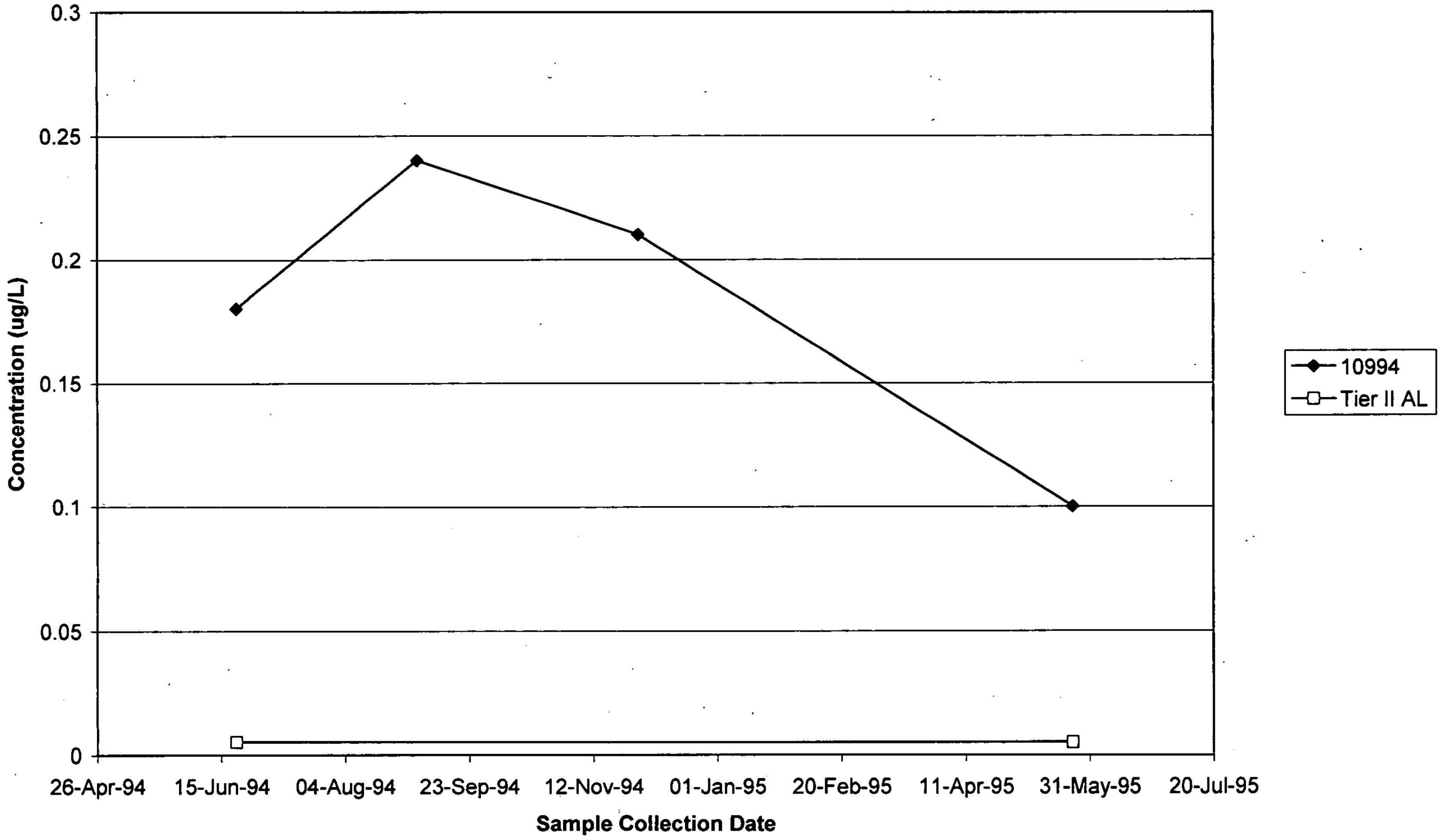

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Figure 4-22 Bis(2-ethylhexyl)phthalate in Groundwater at Wells with a Tier II Exceedance

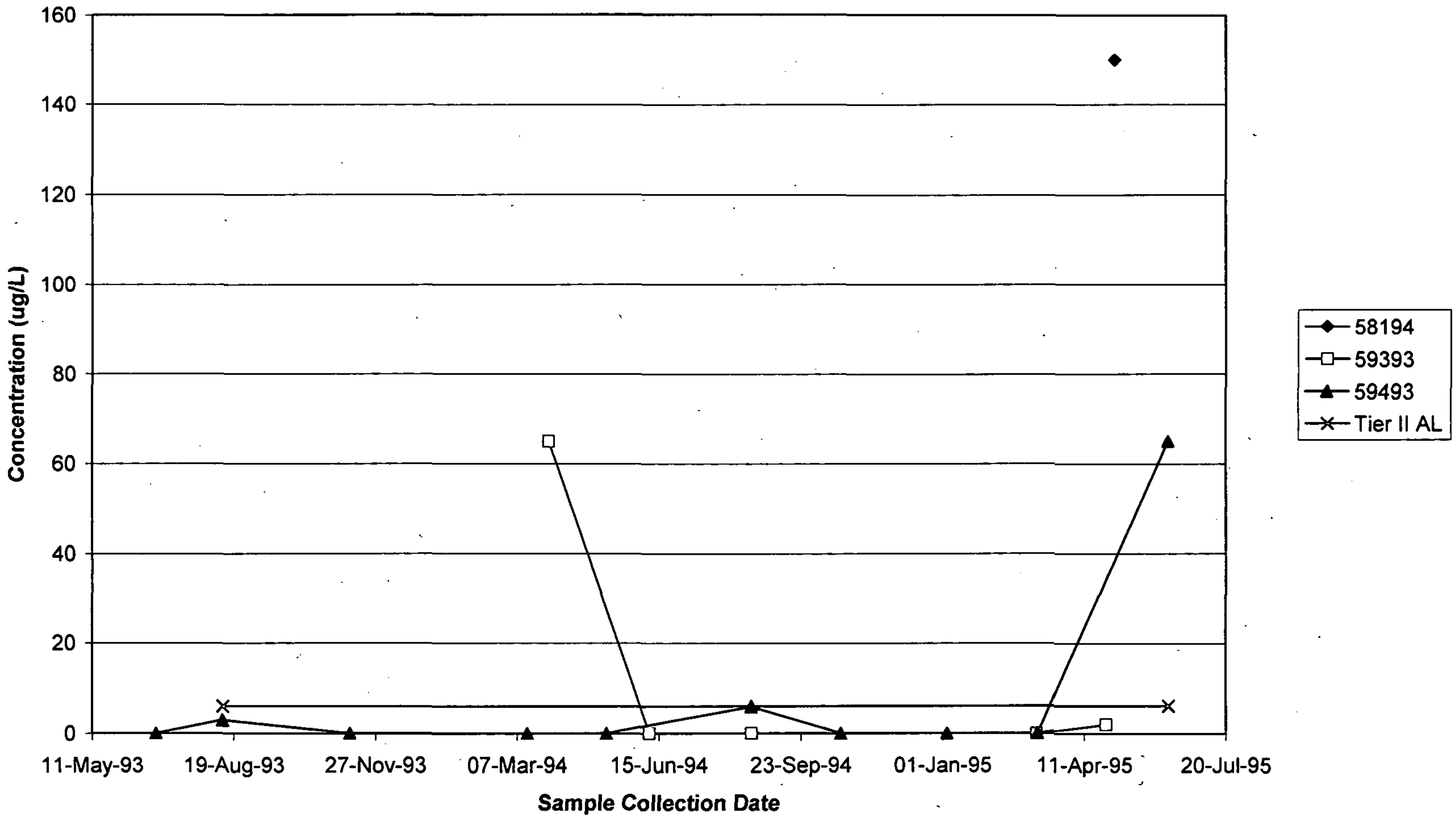

Figure 4-23 Tetrachloroethene in Groundwater at Wells with a Tier II Exceedance

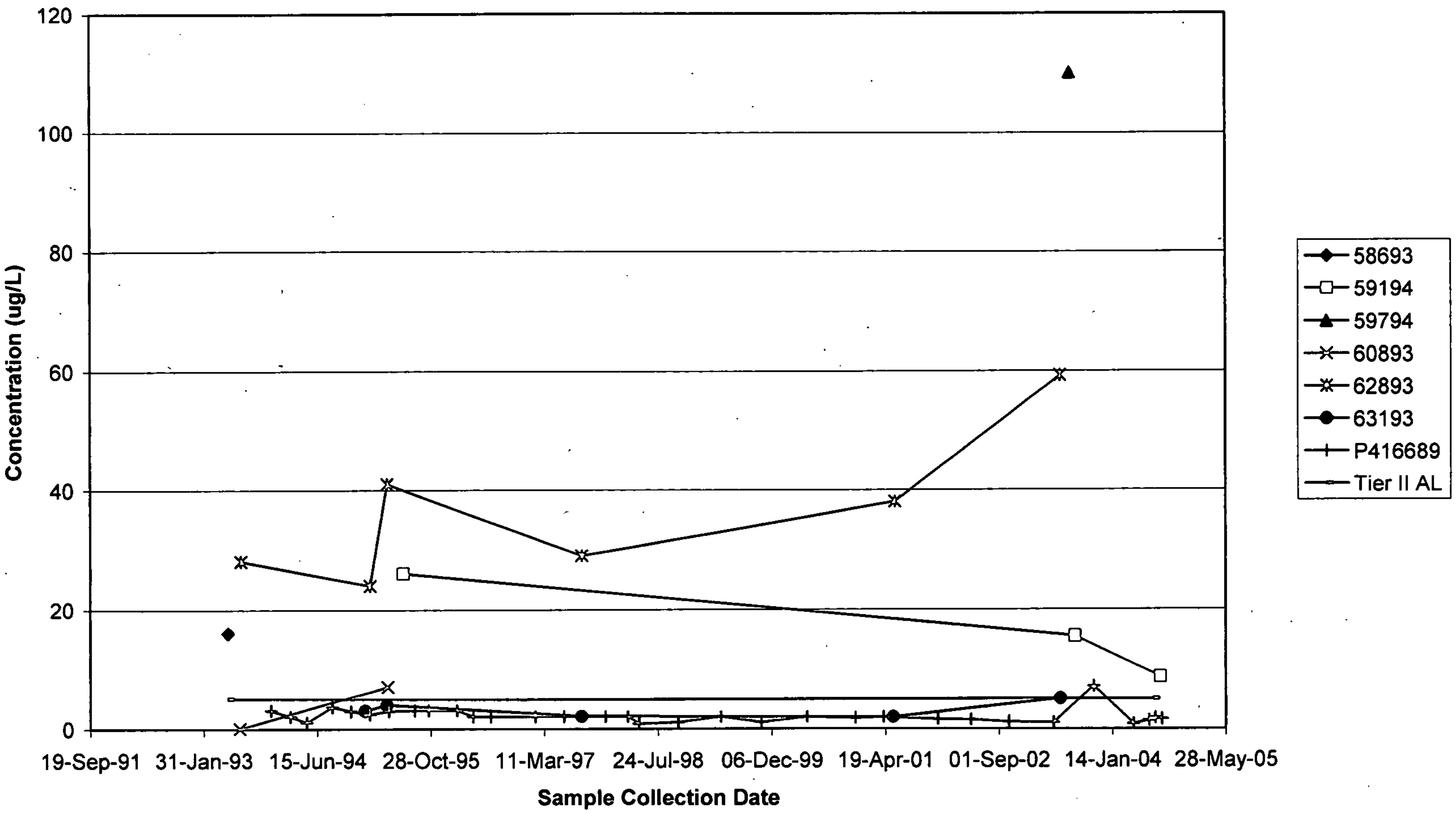

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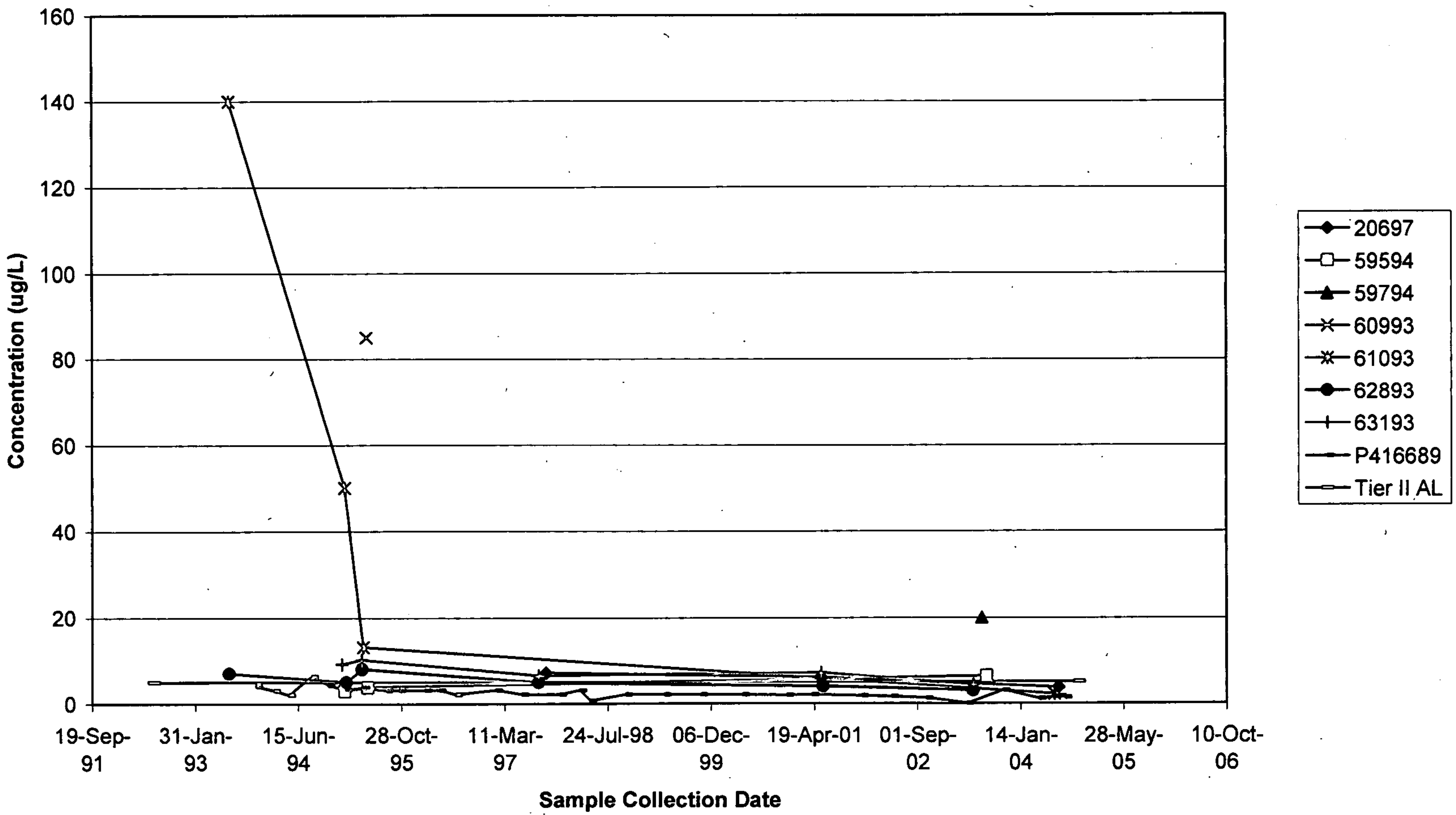
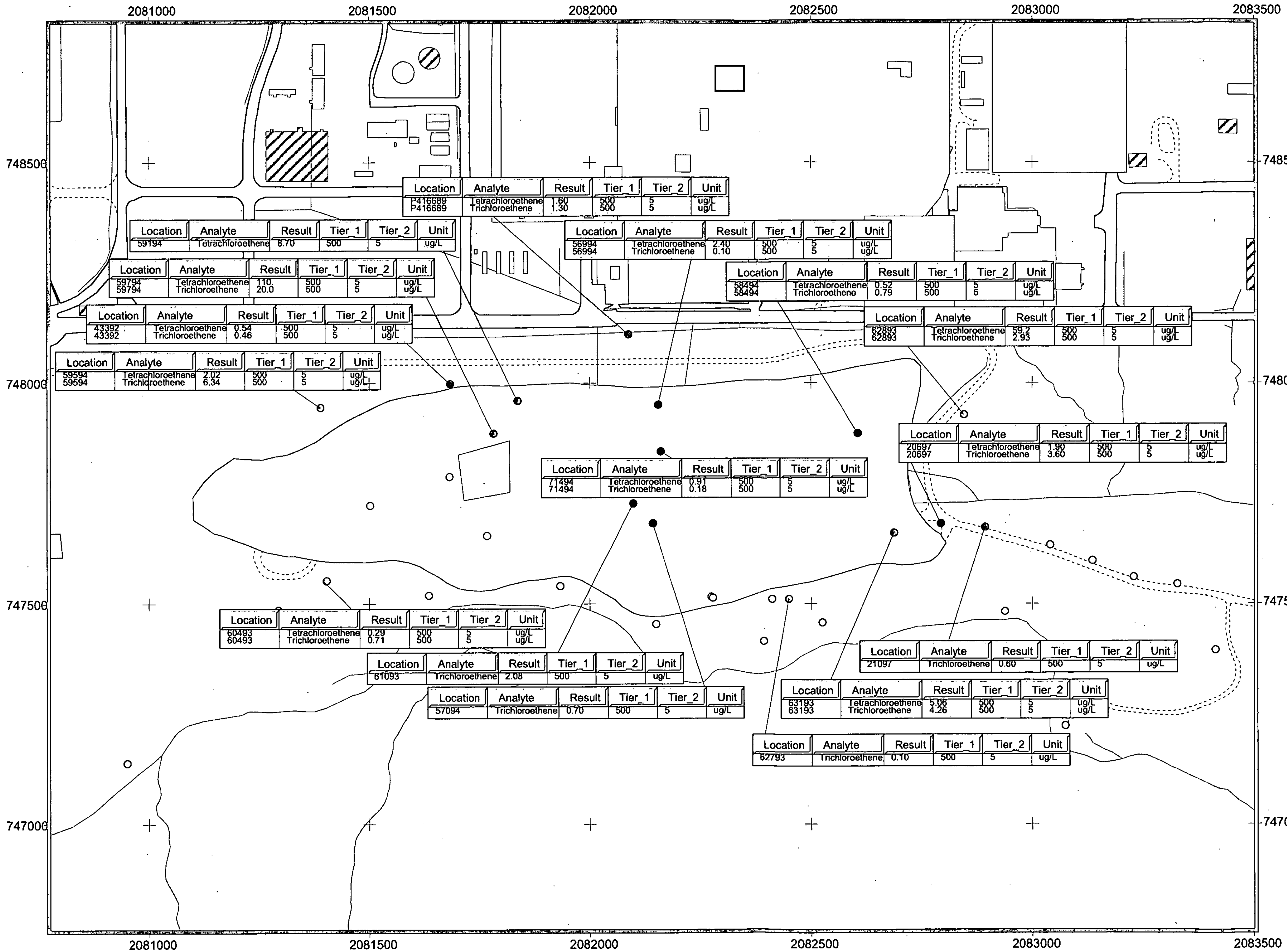
Figure 4-24 Trichloroethene in Groundwater at Wells with a Tier II Exceedance





Location	Analyte	Result	Tier_1	Tier_2	Unit
P416689	Tetrachloroethene	1.60	500	5	ug/L
P416689	Trichloroethene	1.30	500	5	ug/L
59194	Tetrachloroethene	8.70	500	5	ug/L
56994	Tetrachloroethene	2.40	500	5	ug/L
56994	Trichloroethene	0.10	500	5	ug/L
59794	Tetrachloroethene	110.	500	5	ug/L
59794	Trichloroethene	20.0	500	5	ug/L
58494	Tetrachloroethene	0.52	500	5	ug/L
58494	Trichloroethene	0.79	500	5	ug/L
43392	Tetrachloroethene	0.54	500	5	ug/L
43392	Trichloroethene	0.46	500	5	ug/L
62893	Tetrachloroethene	59.2	500	5	ug/L
62893	Trichloroethene	2.93	500	5	ug/L
59594	Tetrachloroethene	2.02	500	5	ug/L
59594	Trichloroethene	6.34	500	5	ug/L
20697	Tetrachloroethene	1.90	500	5	ug/L
20697	Trichloroethene	3.60	500	5	ug/L
71494	Tetrachloroethene	0.91	500	5	ug/L
71494	Trichloroethene	0.18	500	5	ug/L
60493	Tetrachloroethene	0.29	500	5	ug/L
60493	Trichloroethene	0.71	500	5	ug/L
21097	Trichloroethene	0.60	500	5	ug/L
61093	Trichloroethene	2.08	500	5	ug/L
63193	Tetrachloroethene	5.06	500	5	ug/L
63193	Trichloroethene	4.26	500	5	ug/L
57094	Trichloroethene	0.70	500	5	ug/L
62793	Trichloroethene	0.10	500	5	ug/L

Figure 4-25
Most Recent TCE and PCE Concentrations in Groundwater

KEY

- Tier II Exceedance
- Less than Tier II
- Non-detect
- IHSS
- Paved Road
- Demolished building
- Standing building
- Stream
- Dirt Road

Tier II = 5 ug/L for TCE and PCE
Only detected values are shown

DRAFT

N W E S

200 0 200 Feet

Scale = 1: 2750

State Plane Coordinate Projection
Colorado Central Zone
Datum: NAD 27

U.S. Department of Energy
Rocky Flats Environmental Technology Site

Prepared by: RADMS

Date: 10.06.04

Prepared for: KAISER•HILL COMPANY

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Figure 4-26 Nitrate Concentrations in Groundwater at Wells with a Tier II Exceedance

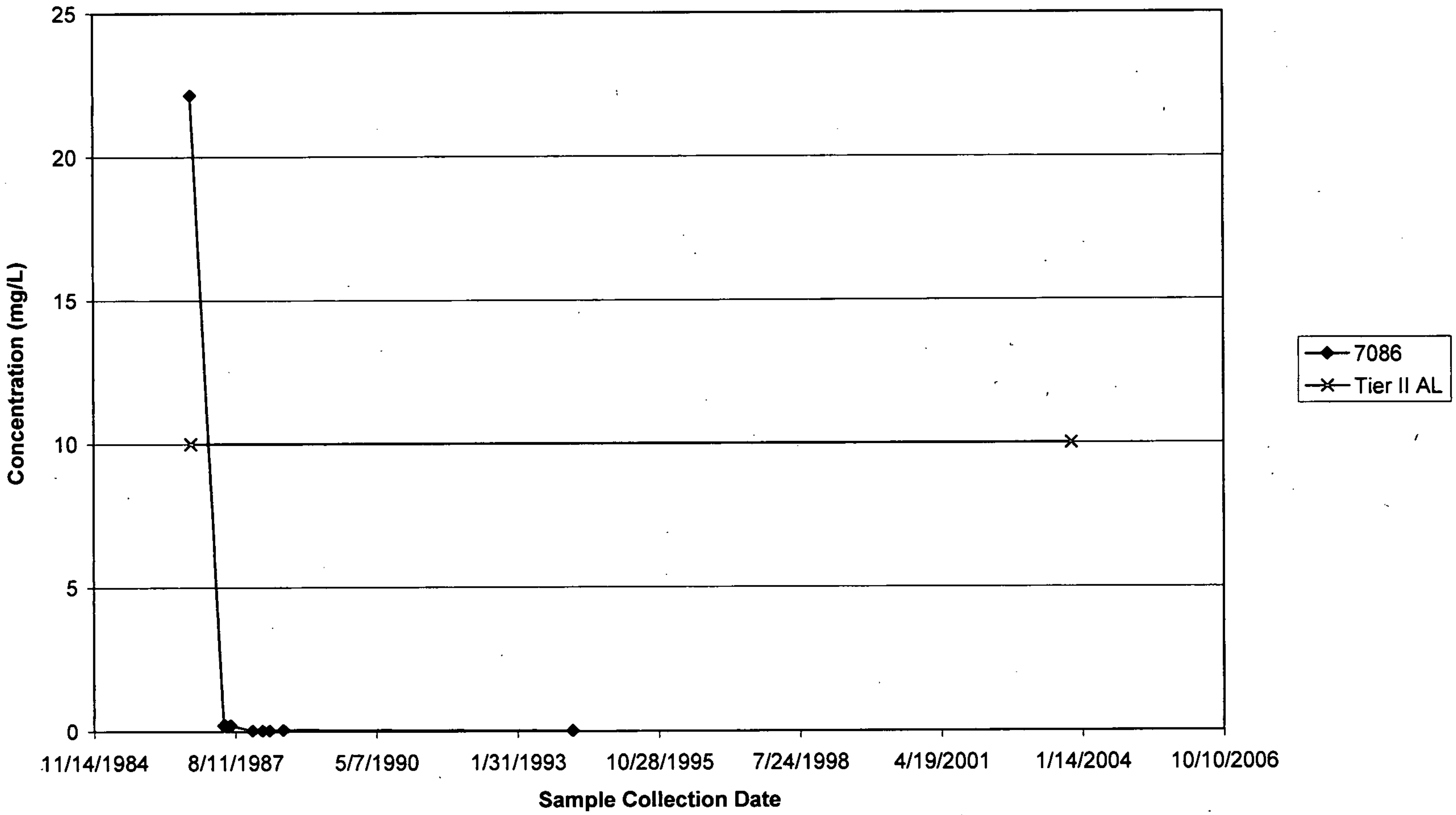
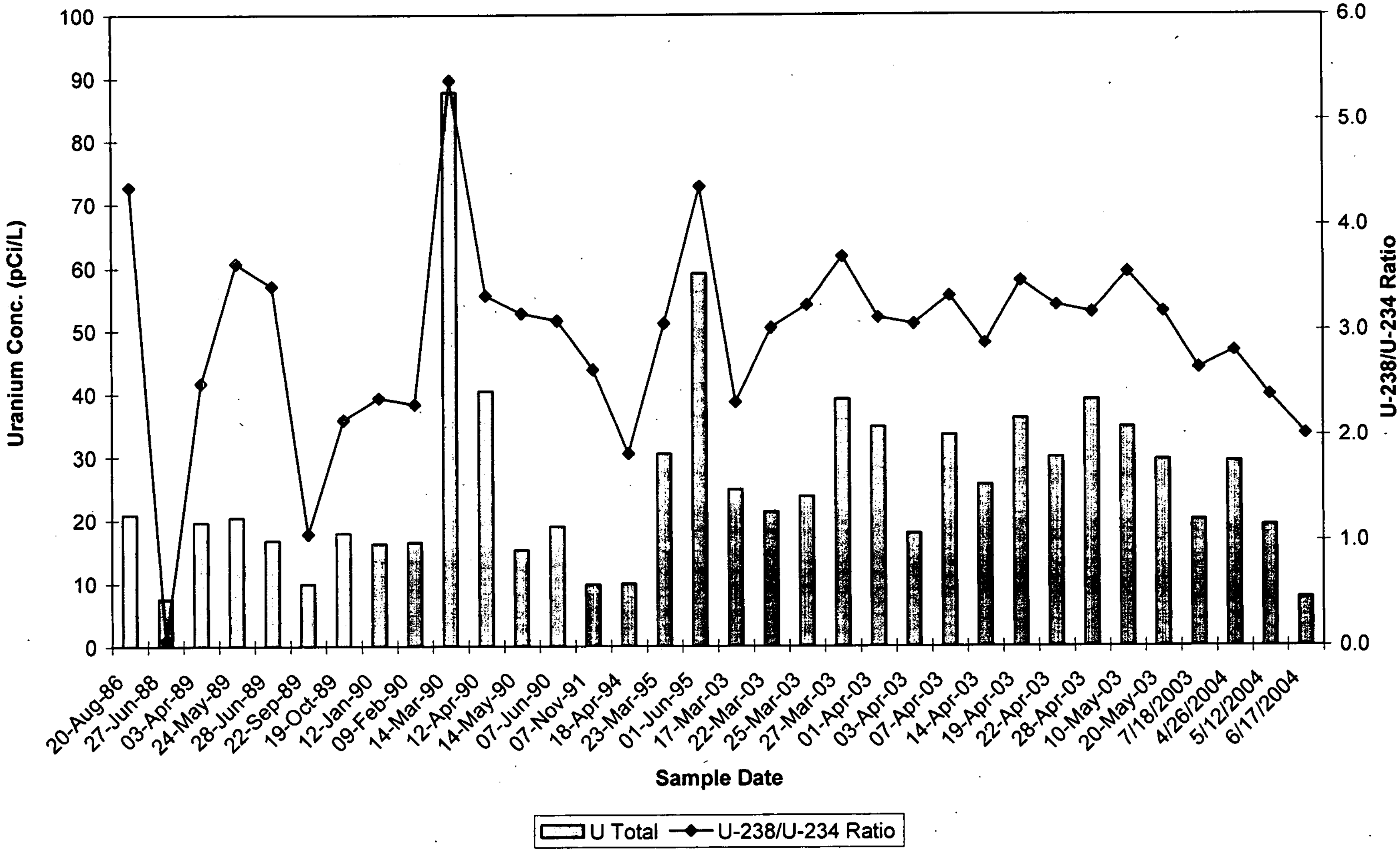


Figure 4-27 Total Uranium Concentrations and Uranium Isotopic Ratios for Surface Water at SW-36



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5.0 REMEDIAL ACTION OBJECTIVES

Based upon an evaluation of the OLF operation and associated waste types as well as the risks posed by exposure pathways from the OLF, an accelerated action consistent with the municipal and military landfill presumptive remedy of source containment after hot spot removal (completed in August 2004) is appropriate for the OLF. The streamlining features for evaluating the contamination source and baseline risks posed to human and ecological health afforded by the landfill presumptive remedy directives have been met by conducting the OU 5 Phase I RFI/RI (K-H 1996). However, the information obtained by the investigation and subsequent monitoring substantiates the application of specific source containment components necessary to address the OLF exposure pathways.

Guidance in the *Application of the CERCLA Municipal Landfill Presumptive Remedy to Military Landfills,* OSWER Directive No. 9355.0-67FS, December 1996, was used to evaluate the characteristics of the OLF in relation to those that affect application of the source containment remedy. The following characteristics are consistent with the relevant guidance for the presumptive remedy:

- Risks are low-level, except for uranium surface "hot spots" (uranium surface soil "hot spots" were removed in August 2004, see Appendix C);
- Treatment of waste is impractical due to its volume and heterogeneity of waste; and unnecessary because the OLF presents limited, to no risk to human health and the environment from waste materials exposed at the surface.
- Waste types include household, commercial (for example, construction debris), non-hazardous sludge, and industrial solid wastes (for example, process wastes, VOCs, paints).
- Small amounts of wastes with hazardous constituents were disposed of in the OLF and the amounts are very small compared with a typical municipal waste landfill.

The guidance notes that some military facilities (for example, weapons fabrication and testing) have a high level of industrial activity compared to overall site activities such that there may be a higher proportion and wider distribution of industrial wastes than at less industrialized facilities. The guidance also notes that some wastes specific to military landfills (for example, low-level radioactive wastes) as long as they are not predominant, can be considered low-hazard and no more hazardous than other waste found in municipal landfills. Other military wastes, such as munitions, chemical warfare agents, and chemicals, are high-hazard wastes and require special consideration. These types of wastes were not disposed of in the OLF.

As described in the OU 5 Phase I RFI/RI Report and Sections 2.0 and 4.0 of this IM/IRA, the types of wastes, levels of contamination, and risks posed by the OLF are similar to those deemed appropriate to implement a presumptive source containment remedy. It is also important to note that the OLF has been closed for approximately 35 years with an inadequate soil cover, limited stormwater run-on and runoff controls, and very little

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maintenance applied, and yet the levels and extent of contamination in environmental media are quite low.

Some surface and subsurface soil samples contained contamination above specific Soil Action Levels in RFETS Action Levels and Standards Framework for Surface Water, Ground Water and Soils, RFCA Attachment 5 (ALF), Table 3, Soil Action Levels. ALF Sections 4.0 and 5.0 require removal of contaminated surface soils to depths specified for non-radioactive and radioactive contaminants. At the OLF, these areas are surface soil "hot spots" that were removed with the approval of the CDPHE, as documented in a RFETS Regulatory Contact Record (see Appendix C).

Deeper soil that are contaminated above soil action levels must be evaluated in accordance with the ALF Figure 3, *Subsurface Soil Risk Screen* and ALF Section 4.2 and 5.3 to determine whether an action is required. For convenience, ALF Figure 3 is included as Figure 5.1. Because soils action levels are exceeded, the OLF fails Screen 1. Since the OLF lies in an erosion area and the waste and commingled soil have become exposed on the surface, the OLF also fails Screen 2. It is assumed that some subsurface soil may exceed soil action levels for depleted uranium, particularly below the surface hot spots, given this, it is likely the OLF fails Screen 3. Under Screen 4, it appears the uranium contamination found at SW-036 could be caused at least in part by surface run off into the SID. While this sampling point is not an ALF Section 2 surface water Point of Compliance or Point of Evaluation, an accelerated action evaluated under Screens 2 and 3 should adequately address this potential contaminant source. For Screen 5, the baseline Ecological Risk Assessment for the Woman Creek Priority Drainage discussed in Section 4. 9 of this IM/IRA concluded that there is not an unacceptable risk to ecological receptors. Additional ecological action levels are being developed and ecological risks will be evaluated in the Accelerated Ecological Screening Process and the Comprehensive Risk Assessment.

The OU 5 Phase I RFI/RI concluded that the OLF does not generate hazardous concentrations of landfill gas, thus gas collection or treatment action is not required.

Groundwater at the OLF contains concentrations of some organic compounds and metals, including depleted uranium, greater than background and ALF Table 2, Action Levels for Groundwater. However, this contamination does not generate an expanding plume of groundwater contamination outside of the OLF source area and does not adversely impact surface water quality or present an exposure pathway outside of the OLF source area. In accordance with ALF, Section 3.3.C.2, groundwater plumes that can be shown to be stationary and do not therefore present a risk to surface water, regardless of their contaminant levels, do not require mitigation or management. They do require continued monitoring to demonstrate that they remain stationary. Groundwater at the OLF is not a drinking water source and could not sustain any prolonged use, such as for a drinking water.

Based upon the foregoing evaluation, risks posed by the OLF will be addressed by the proposed accelerated action. The proposed action is to implement "hot spot" removal (completed August 2004) and the presumptive remedy of source containment. There are two pathways of exposure to be addressed by the accelerated action:

- direct exposure to disposed waste and commingled soil; and

- surface erosion and runoff of contaminants into surface water.

Therefore, the Remedial Action Objectives (RAOs) for the OLF are to:

- Prevent direct contact with landfill soil and commingled waste and
- Control erosion caused by Stormwater run-on and runoff.

In addition to the "hot spot" removal (completed in August 2004), components of the source containment remedy that are necessary to address the RAOs are:

- a stable landfill cover to prevent direct contact with landfill soil or debris;
- a landfill cover that adequately controls erosion caused by stormwater runon and runoff; and
- institutional controls to supplement engineering controls to appropriately monitor and maintain the landfill cover.

In addition to these components, groundwater and surface water monitoring will be conducted. Additional evaluation and a description of the presumptive remedy components and alternatives are presented in Sections 6.0 through 10.0.

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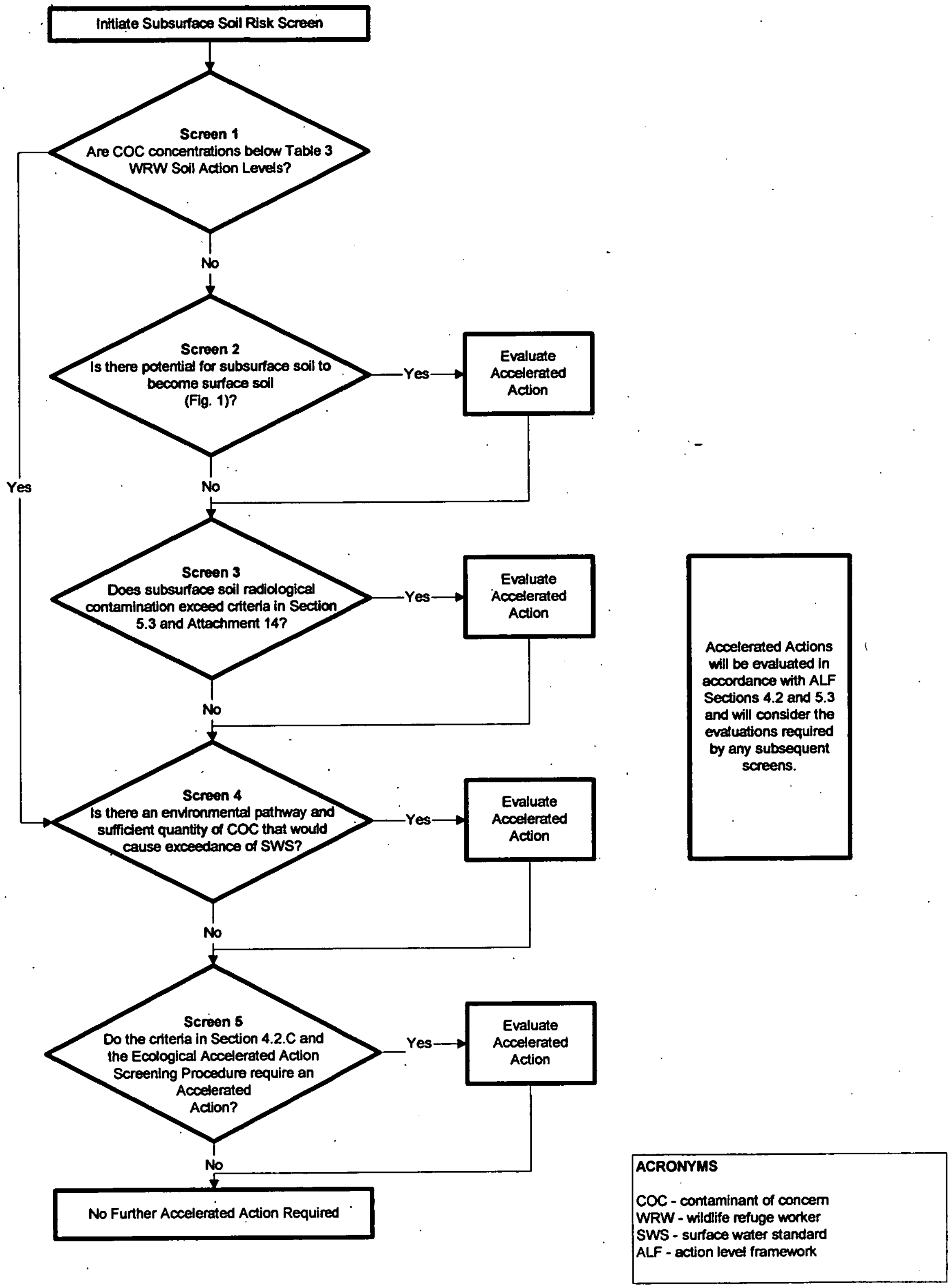
Figure 5-1 Subsurface Soil Risk Screen



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6.0 REMEDIAL ACTION ALTERNATIVES EVALUATION

This section describes the remedial action alternatives considered for the OLF (IHSS 115) and Filter Backwash Pond (IHSS 196) and presents a comparative analysis of the alternatives in accordance with the CERCLA guidelines, the remedial action objectives, and applicable or relevant and appropriate requirements (ARARs).

6.1 Remedial Action Alternatives

This section presents four remedial action alternatives for the OLF. The alternatives include leaving the waste in an undisturbed state, leaving the waste in place with a protective soil cover, combining a buttress fill with a soil cover, and total removal.

6.1.1 Alternative 1 – No Action

Alternative 1 minimizes direct contact of wastes remaining at the site by limiting access to the OLF. All waste would be left in place as is currently the situation and site features, such as Woman Creek and the SID, would not be disturbed. The PMJM protection area would also not be disturbed. Because waste would be left in place, institutional controls and site monitoring are considered part of this alternative.

Institutional Controls

Institutional controls would be used at the site to provide short- and long-term protection of human health and the environment. Institutional controls include administrative and/or legal controls that minimize the potential for human exposure to contamination by limiting land or resource use. Land use restrictions would be required to restrict use of the area. In addition, advisories, or warnings that provide notice to potential users of the land, surface water, or groundwater would be necessary.

Site Monitoring

The current conditions of surface water, groundwater and soil erosion at the OLF would be monitored to track any changes that might result in an adverse condition. Monitoring would be instituted through the current RFETS Integrated Monitoring Program (IMP) and ultimately in Sitewide post-closure regulatory documents. Additional monitoring wells could be installed, if needed, to provide sufficient coverage to monitor changes in groundwater quality. In addition, an annual inspection of the area would be conducted to identify any visual changes at the OLF. An annual ground topographic survey would be completed to monitor slope stability.

6.1.2 Alternative 2 – Soil Cover

This alternative consists of the removal of surface soil "hot spots," (soil removal complete) clearing and grubbing of the landfill area, limited area grading, and implementing the presumptive remedy by placement of a soil cover, cover revegetation, monitoring, and institutional controls.

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Removal of Surface Soil Contaminants

The contaminants exceeding soil action levels are discussed in Section 4.3.

The surface soil hot spots were removed in August 2004. Appendix C describes the removal efforts and presents the confirmation sampling results

Area Grading & Soil Cover

The waste fill area would be graded to generally an 18-percent (5.5:1) slope, or less, using a cut-and-fill approach that would be as balanced as possible. A conceptual grading plan and cross-section are shown on Figures 6-1 and 6-2, respectively. Standard earth-moving equipment, such as dozers, hoes or scrapers, would be used to cut areas where the slope exceeds the desired 18 percent and fill those areas where the slope is less than the desired 18 percent slope. It is estimated that approximately 55,000 cy of waste fill material would be moved during the process and 105,000 cy of fill would be required to reach the 18-percent grade before placing the 2-ft cover.

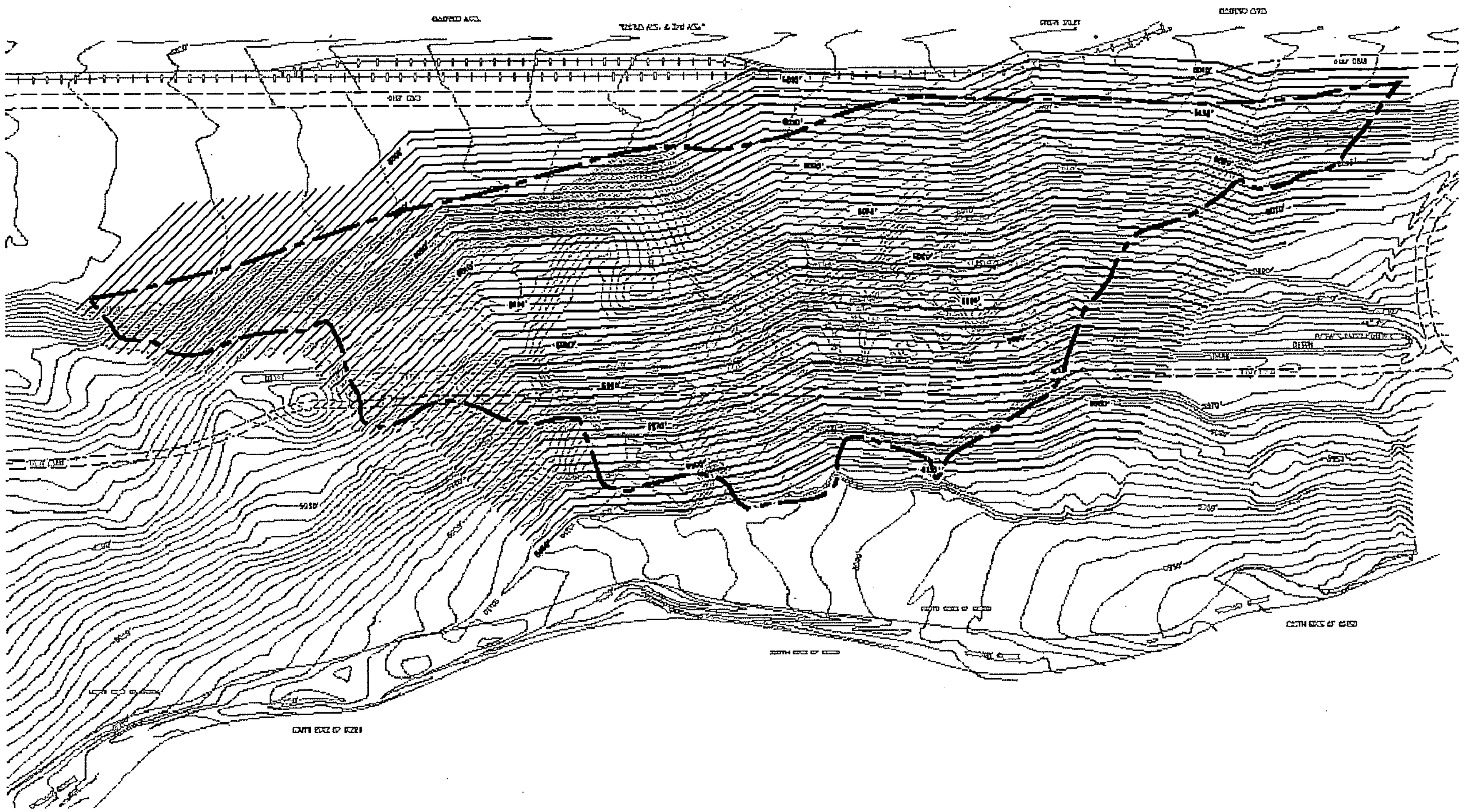

Figure 6.1
Conceptual Surface Grading Plan

Note: The grading plan will be optimized during the design.

N

60 0 60 120 FEET

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Prepared by:

CH2MHILL

Prepared for:

KAISER-HILL

October 18, 2004

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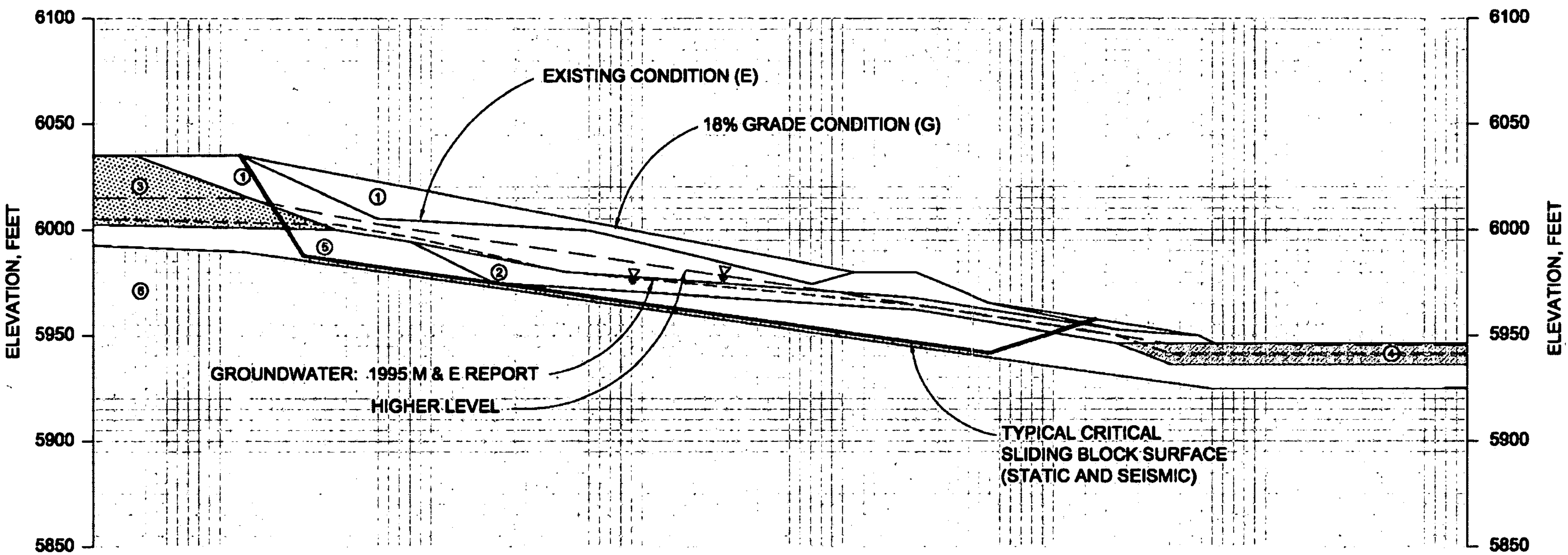

Figure 6.2
Typical Conceptual Cross - Section of Landfill Graded Surface

Note: The grading plan will be optimized during the design.

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October 18, 2004

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Control measures would be implemented during the grading process to control the spread and release of waste materials in the OLF. The control measures would include the establishment of work zones, decontamination procedures, dust suppression methods, traction mats, visual inspections, and radiological surveys. Work would be suspended when environmental conditions could greatly increase the possibility of the spread of contaminated materials. Monitoring would be performed, as necessary, to verify that there has been no release of contaminated materials.

After the grading of the landfill surface is complete, a soil cover will be placed over the landfill to a minimum thickness of 2 ft. About 65,000 cubic yards of local or onsite soil will be used to construct the cover. The soil cover will be compacted sufficiently to provide a stable cover system to promote surface water runoff, reduce surface water ponding, increase overall slope stability, and provide a suitable soil surface for revegetation.

Revegetation of the soil cover with native species will reduce infiltration and control erosion. The seeding will be conducted ,along with erosion control matting or mulch to prevent erosion of the cover while allowing the vegetation to establish a strong stand.

Institutional Controls

Post-accelerated action institutional controls will be implemented. These controls consist of access controls, continued DOE jurisdiction, and controls to prevent drilling, excavation, or disruption of the cover or sampling stations. Routine monitoring and inspection of implemented controls will be performed.

6.1.3 Alternative 3 – Soil Cover With Buttress Fill

All the components of Alternative 2 (Section 6.1.2) are included in Alternative 3. Additional features of Alternative 3 include the construction of a buttress fill at the toe of the regraded surface of the OLF and the possible construction of an upgradient groundwater "cutoff" wall immediately north of the OLF.

Buttress Fill

A structural soil fill would be built at the toe of the OLF regraded surface as conceptually depicted on Figure 6-3. The buttress fill would be either placed on top of the weathered bedrock or just beneath the weathered bedrock on top of the unweathered bedrock. The buttress fill would be built by placing specified structural fill soil in loose lifts and compacting thelifts to a desired relative compaction requirement.

If it was determined during the design of the buttress fill that the buttress would be placed through the weathered bedrock on top of the unweathered bedrock, trench boxes or other structural support methods could be required to allow excavation of the weathered bedrock. These special construction provisions would be needed to prevent movement of the waste fill above the weathered bedrock excavation into the buttress construction area.

A rock layer and strip drains would be placed under and upgradient of the buttress fill to reduce and control the hydraulic head behind the buttress fill. These drainage layers are

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needed to prevent water saturation of the fill soil and eliminate any seepage flow through or around the buttress fill.

Upgradient Groundwater "Cut-off" Wall

An upgradient groundwater "cut-off" wall would be considered with this alternative to further control the lateral inflow of groundwater into the OLF. A wall for this purpose would be constructed of a soil/bentonite type slurry keyed into the weathered bedrock. However, the groundwater modeling indicates that the impact on groundwater levels in the OLF from the construction of such a wall would be very minimal and on the order of less than 3 ft.

6.1.4 Alternative 4 – Removal of Waste

The objective of this alternative is to remove the entire waste fill from within the OLF area and restore the hill slope. The remedial measures would consist of the following five activities:

- Preparation of the site;
- Excavation of contaminated debris and soil;
- Characterization and segregation of waste fill debris and soil;
- Off-site disposal of waste fill debris and contaminated soil; and
- Restoration of disturbed areas.
- It is estimated that approximately 192,000 cubic yards (bulking of 160,000 cubic yards of commingled soil) of waste fill debris and soil would be excavated, characterized, and transported to an off-site, licensed disposal facility. The volumes of radioactive and nonradioactive contamination in the waste fill are currently unknown, but would be determined during implementation. These remedial measures would be completed in approximately 3 years. Specific activities to implement this alternative are described below.

Site Preparation

Prior to excavation of the waste fill debris and soil, the site would be prepared. First, access roads and storage areas would be constructed. Second, the area to be excavated would be cleared and grubbed, and surface water control features would be constructed. The procedures used to complete these tasks are described below.

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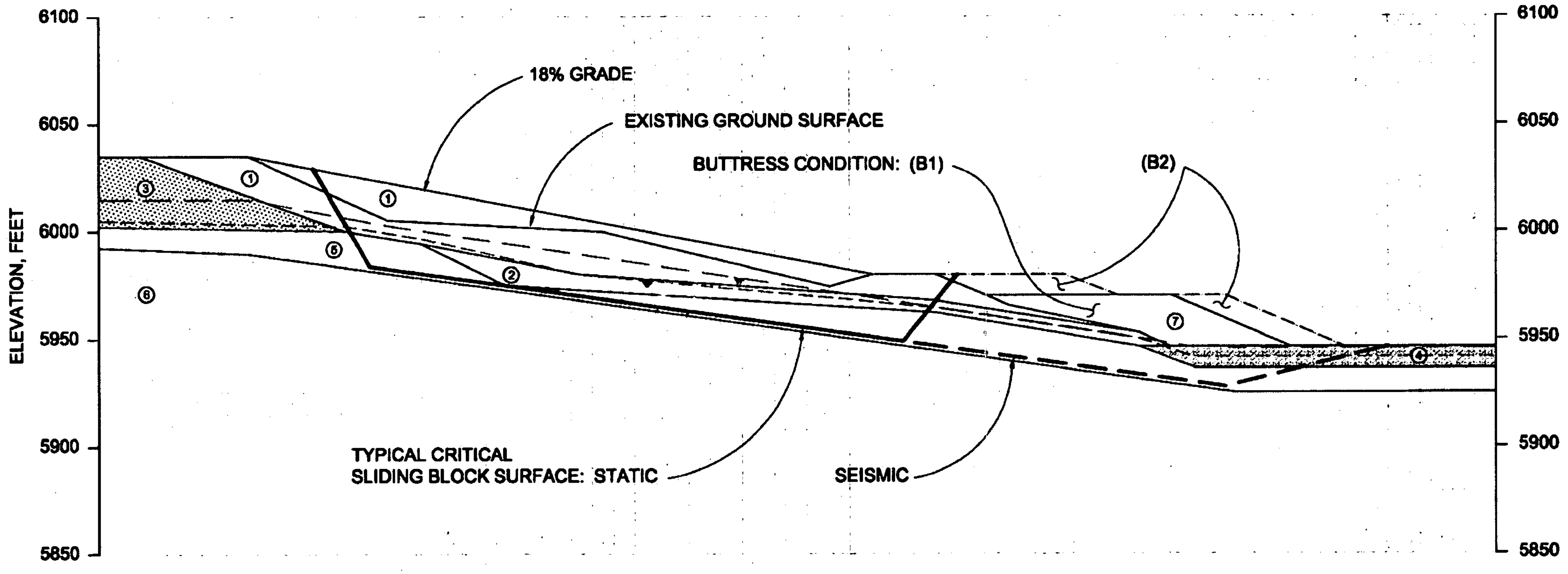
Figure 6.3
Typical Conceptual Cross - Section of Regraded Landfill Surface with a Buttress fill



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GIS Dept. 303-966-7707

Prepared by: CH2MHILL

Prepared for: KAISER-HILL

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Construction of Storage Areas and Access Roads

A storage area would be located north of the OLF boundary. It is estimated that three to four acres would be required to accommodate the required equipment, supplies, and construction offices to stage and characterize the removed waste materials and soil.

In addition, this alternative would require the construction of three new access roads. The first new access road would be constructed to connect the existing access road that runs east-west through the center of the OLF to the waste fill area located in the northeastern section of the landfill. The second new access road would be located south of the OLF boundary to connect the existing access road to the waste fill area located in the southern section of the landfill. The third new access road would be located on the western edge of the OLF boundary to connect the existing access road to the stockpile area. The combined length of these new access roads would be approximately 2,000 ft. The maximum grade of the new roads would not exceed 7 percent, and the design would allow for drainage of surface water while the roads were in use.

Clearing, Grubbing, and Stockpiling

A stockpile area would be located on the terrace immediately northwest of the IHSS boundary. It would be approximately two acres in size and would accommodate up to 20,000 cubic yards of waste fill material at any given time during the project.

The area within the OLF boundary would be cleared and grubbed of vegetation, debris, loose rocks, and other items that would interfere with the waste fill removal process. The cleared materials would be transported to the stockpile area for characterization prior to disposal. Surface water would be directed around the stockpile and excavated areas.

Excavation of Contaminated Waste Fill Debris and Soil

The area that would be excavated is shown on Figure 1-2. The waste fill within this area would be stripped and placed into temporary stockpiles using standard equipment, such as crawler-type dozers, track-type loaders, and track-mounted excavators. The machines utilized would be small enough to ensure a high degree of cut accuracy and a minimum amount of over excavation. Trucks or large-capacity wheel loaders would be used to move the waste fill from temporary stockpiles to the primary stockpile area located immediately northwest of the OLF boundary.

Excavated areas would be carefully inspected visually and with field instrumentation to determine the outer limits of the waste fill area. Confirmation sampling and analysis would be then conducted to verify that radioactive and nonradioactive waste materials have been adequately removed.

Characterization of Waste Fill Debris and Soil

The waste fill material removed from the OLF during the grubbing and excavation processes would be characterized at the stockpile area using a two-step process. First, field screening techniques would be used to determine the radioactivity of the stockpiled materials. Second, samples would be collected and analyzed to determine if the material is a characteristic RCRA hazardous waste. Potential hazardous waste would be further characterized using the Environmental Protection Agency (EPA) TCLP analysis.

Disposal of Waste Fill Debris and Soil

Following characterization, each pile of waste fill material would be classified for disposal. Items determined to be radiologically contaminated or that exhibit a toxicity characteristic would be transported to an appropriately licensed facility for final disposal. Items determined not to be radiologically contaminated or that do not exhibit a toxicity characteristic would be managed as solid waste. Waste material classified as solid waste and meeting disposal facility waste acceptance criteria would be disposed of at a local sanitary landfill.

Restoration of Disturbed Areas

Following completion of remediation activities, the disturbed areas would be reclaimed. This process would require some grading and backfilling of the area prior to seeding and revegetation. The seeding and revegetation process would be the same as described in Section 6.1.2.

6.2 COMPARATIVE EVALUATION OF ALTERNATIVES

This section provides a comparative evaluation of the remedial alternatives using the criteria of effectiveness, implementability, slope stability, and relative cost. A summary of the comparative evaluation is provided in Table 6-1.

The relative cost estimates provided in this report are preliminary, and are provided primarily for the purpose of comparing the various remedial action alternatives. The final actual costs of a remedial alternative will depend upon the labor and material costs, site conditions, productivity, and competitive market conditions for contractors at the time of implementation, as well as the final project scope, final project schedule, final engineering design, and other variable factors. As a result of these uncertainties, the final costs will vary from the estimates provided herein.

Estimated costs of the alternatives include indirect capital costs, direct capital costs, and annual costs. Estimated costs were prepared utilizing estimated volumes, vendor quotes, available literature, Means Cost Data guides (R.S. Means Company 2001), and other sources deemed appropriate.

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Table 6-1
Summary of Comparative Evaluation of Potential Remedial Alternatives

Criteria	Alternative 1 No Action	Alternative 2 Limited Grading & Soil Cover	Alternative 3 Limited Grading, Soil Cover & Buttress Fill	Alternative 4 Removal with Off-Site Disposal
Effectiveness	**Low**	**Moderate**	**Moderate**	**High**
Protection of Public Health and Environment	Current wastes remain exposed and potential erosion continues; however, OLF currently exhibits limited to no impact on public health and the environment.	Exposed wastes are covered and further slope erosion is eliminated to exposed wastes in the future.	Exposed wastes are covered and further slope erosion is eliminated to exposed wastes in the future. Buttress fill provides some increase in overall slope stability but impacts more of the PMJM habitat and wetlands areas	All waste removed from area.
Long-Term Effectiveness and Permanence	No long-term protection provided due to exposed waste.	Proven technologies over the long term implemented.	Proven technologies over the long term implemented.	Removes all waste from the area.
Short-Term Effectiveness	Low due to exposed waste; however, PMJM and wetlands would not be affected.	Moderate to High short-term effectiveness since risks associated with some limited movement of waste materials. PMJM and wetlands mitigation required.	Additional risk to workers during construction of buttress fill. Additional PMJM and wetlands mitigation required.	Low short-term effectiveness due to the potential to release contamination from the excavation and movement of waste materials. PMJM and wetlands mitigation required.
Compliance with Remedial Action Objectives	Would not comply RAOs.	Will comply with RAOs.	Will comply with RAOs.	Will comply with RAOs.
Implementability	**High**	**Moderate/High**	**Moderate/Low**	**Low**
Technical Feasibility	Technically feasible	Technically feasible	Technically feasible	Technically feasible
Maintenance and Monitoring Requirements	Annual inspection, maintenance, and repair on as-needed basis	Periodic inspection, maintenance, and repair on as-needed basis	Periodic inspection, maintenance, and repair on as-needed basis	No maintenance or monitoring required
Construction Feasibility	Construction is feasible	Construction is feasible	Construction feasible, but more difficult.	Construction is feasible but much more difficult and time consuming
Availability of Services and Materials	All materials locally available	All materials locally available	All materials locally available	Disposal facilities available in U.S
Administrative Feasibility	Not administratively feasible	Administratively feasible	Administratively feasible	Administratively feasible
Stability	**Moderate**	**High**	**High**	**Moderate**
Static Factor of Safety	1.3 – 1.5	1.5 – 1.7	1.7 – 1.9	Not applicable
Seismic Factor of Safety	0.7 – 0.8	0.9	0.9 – 1.0	Not applicable
Estimated Deformation	10" – 12"	5" – 10"	3" – 5"	Not applicable
Capital Cost*	**$50,000 to $60,000**	**$4.0 MM to $4.6 MM**	**$6.0 MM to $6.9 MM**	**$100 MM to 260 MM**
O&M Cost ($/yr)	**$25,000**	**$31,000**	**$31,000**	**$0**
Present Worth Cost**	**$800,000 to $810,000**	**$4.93 MM to 5.53 MM**	**$6.93 MM to $7.83 MM**	**$100 MM to 260 MM**
Regulatory/ Community Acceptance	**Low**	**Moderate**	**High**	**Moderate**

* Costs are in 2004 dollars.
** Assumes 30 years of O&M without an escalation factor

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6.2.1 Alternative 1 – No Action

This alternative, as presented in Section 6.1.1, consists of only institutional controls and monitoring.

<u>**Effectiveness**</u>

Effectiveness considers whether the alternative provides protection of human health and the environment, and achieves the remedial objectives.

Protectiveness

The No Action Alternative would leave the waste in place as it exists today and allow for potential release of contaminants; however, as presented in Section 4.0, the OLF currently exhibits limited to no impact on human health and the environment. Alternative 1 would attain all Applicable and Relevant and Appropriate Requirements (ARARs), except those relative to the landfill cover. Institutional controls, such as signs and other barriers would help to reduce human exposure to the waste materials. However, wildlife workers and trespassers may occasionally enter the area and could potentially come in contact with the OLF debris.

In the short term, there would be low risks to the workers and public during the implementation of this alternative, and no impact on the Preble's Meadow Jumping Mouse habitat south of the OLF or to wetlands within the OLF.

Alternative 1 is not considered effective in the long term. Potential exposure to OLF debris and continued surface erosion would remain; however, as presented in Section 4.0, the OLF currently exhibits limited to no impact on human health and the environment. Alternative 1 would continue to provide existing habitat for the PMJM without disruption, and would not disturb or destroy the wetlands at the OLF. Institutional controls and monitoring would provide for some continuing protection.

Achieve Remedial Objectives

Alternative 1 would not comply with the RAOs of preventing direct contact with the landfill waste or controlling the existing surface erosion patterns. However, as presented in Section 4.0, the OLF currently exhibits limited to no impact on human health and the environment.

<u>**Implementability**</u>

Implementability addresses the technical and administrative feasibility of implementing an alternative using the required equipment, services, and materials.

Technical Feasibility

Alternative 1 is technically feasible because no construction activities would be required except for the fabrication and installation of signs and possibly barriers. With this limited construction, the PMJM habitat and wetlands would remain undisturbed. However, Alternative 1 would provide monitoring of the long-term physical features

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of the OLF to identify any detrimental changes. Maintenance of the institutional controls implemented would be considered minimal.

Availability

Alternative 1 would only require materials for signs and possibly barriers to implement institutional controls. These materials are readily available. Monitoring would use industry standard equipment and materials that are also readily available.

Administrative Feasibility

The implementation of Alternative 1 does not require permits or easements, and does not impact adjoining property. It will not inhibit the ability to impose institutional controls. Existing site management and access controls would be maintained until a comprehensive final plan is implemented in the future. The alternative is generally consistent with the aesthetic qualities of the facility end use as a wildlife refuge.

Alternative 1 would most likely not meet CDPHE, EPA, and community acceptance because debris is left exposed at the surface of the OLF and surface erosion would most likely continue.

Cost

Evaluation of costs should consider the capital costs to engineer, procure, and construct the required equipment and facilities, and the operating and maintenance costs associated with the alternative.

Capital Cost

The capital cost to implement Alternative 1 is between $50,000 and $60,000.

Operation & Maintenance Cost

The operation and maintenance costs associated with this alternative involve inspection of the OLF surface and maintenance of the groundwater and surface water monitoring stations. Sampling and analysis of groundwater and surface water is also included. Operation and maintenance costs are estimated to be approximately $25,000 per year; however, additional costs could be incurred to address any hazards exhibited by the wastes continuing to be exposed.

Summary – Alternative 1

Alternative 1 was not retained for further consideration because the OLF debris remains exposed and potential surface erosion would continue. The OLF currently exhibits little to no impact on human health and the environment.

6.2.2 Alternative 2 – Soil Cover

Alternative 2, Soil Cover is presented in Section 6.1.2 and generally includes the removal of radiologically contaminated surface soil (completed in August 2004), limited site grading, placement of a 2-ft-thick soil cover, and revegetation of the soil cover.

Effectiveness

Effectiveness considers whether the alternative provides protection of human health and the environment, and achieves the remedial objectives.

Protectiveness

Alternative 2 would provide a higher overall level of protection than Alternative 1 because the waste would be covered, eliminating direct contact with the OLF debris. The radiologically contaminated soil has already been removed. Alternative 2 would comply with ARARs. The stabilization of the hillside would add additional long-term protection of the waste fill area by reducing the possibility of movement and erosion. Potential remediation worker exposure would be higher during implementation of Alternative 2 than during Alternative 1 because of the movement of waste during the regrading operations. However, appropriate safety measures will be employed to protect the worker during construction.

The regraded surface provides for a more stable configuration. Static factors of safety[8] are estimated to be from 1.5 at "wet-year" groundwater levels to 2.2 during "dry-year" conditions. Also, the seismic factors of safety are estimated at 1.0 to 1.2 with a possible corresponding deformation range of 9 to 6 inches. The seismic calculations assume a 0.12 (Xg, gravity) peak acceleration coefficient, which has a 2-percent probability of occurring every 50 years (ref. for Geotech report).

Alternative 2 would have low to moderate short-term effectiveness. This alternative has a chance of impacting workers, the public, and the environment during implementation. Most of the potential health impacts would be due to potential inhalation of fugitive dust and the ingestion of dust and contaminated materials (hand to mouth). However, health and safety controls would be readily implemented to protect workers and the public. A site-specific Health and Safety Plan (HASP) would be developed for the site that addresses worker safety including dust monitoring, decontamination procedures, etc. Also, engineering controls, such as the addition of water to disturbed areas, would be implemented to control dust. During the implementation of these alternatives, there would also be the potential for short-term impacts to the environment due to spills, dust, and surface runoff from disturbed areas. These impacts would be readily controlled through appropriate transportation and engineering practices, such as covering of loads, onsite spill cleanup, dust control measures, erosion protection, silt fences, etc. In addition, construction activities would remove some jurisdictional and candidate wetlands and a portion of the PMJM protection area within the boundary of the OLF.

Alternative 2 will provide a long-term cover over the currently exposed OLF debris and eliminate the current erosional conditions. However, because the OLF (as presented in Section 4.0) currently exhibits limited to no impact on human health and the environment, Alternative 2 provides containment of the OLF materials consistent with the presumptive remedy discussed in Section 1.1. Alternative 2 would rely upon proven technologies for slope stabilization and landfill covering. Infiltration of

[8] The factor of safety is the ratio of the force resisting movement to the force causing movement.

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surface water would be reduced through installation of a soil cover with a consistent grade.

Achieve Remedial Objectives

Alternative 2 will meet all of the remedial action objectives. The Landfill will be covered with an appropriately designed soil cover to prevent contact with the waste materials. Construction activities will remove wetlands and a portion of the PMJM protection area within the boundary of the OLF; however, the PMJM habitat would return after construction of the action.

Implementability

Implementability addresses the technical and administrative feasibility of implementing an alternative using the required equipment, services, and materials.

Technical Feasibility

Alternative 2 is technically feasible using proven controls and engineering design features that have been successfully implemented at other sites with similar conditions. All controls within the alternative could be executed using readily available machinery, including earthmoving equipment, haul trucks, and other conventional construction equipment.

Alternative 2 will require maintenance of the cover through routine inspections and repair as needed. Monitoring of groundwater and surface water would be required; however, the requirements would be slightly less than for Alternative 1 because of the containment provided by Alternative 2.

Availability

For Alternative 2 mainly natural materials are required. The cover materials would either come from an on-site borrow source, or a borrow source close to the site. Monitoring would use industry standard equipment and materials that are also readily available.

Administrative Feasibility

The implementation of Alternative 2 does not require permits or easements, and does not impact adjoining property. It will not inhibit the ability to impose institutional controls. Existing site management and access controls would be maintained until a comprehensive final plan is implemented in the future. The alternative is consistent with the aesthetic qualities of the facility end use as a wildlife refuge.

Alternative 2 will remove jurisdictional wetlands and a portion of the PMJM protection area.

Alternative 2 would most likely gain CDPHE, EPA, and community acceptance.

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Cost

Evaluation of costs should consider the capital costs to engineer, procure and construct the required equipment and facilities, and the operating and maintenance costs associated with the alternative.

Capital Cost

The capital cost to implement Alternative 2 is between $4,000,000 and $4,600,000.

Operation & Maintenance Cost

The operation and maintenance costs associated with this alternative involve inspection and maintenance of the cover. Other monitoring costs, such as groundwater and surface water monitoring would also be included. Operation and maintenance costs are estimated to be $31,000 per year.

Summary – Alternative 2

Alternative 2 implements the presumptive remedy, meets all of the remedial action objectives and attains the ARARs.

6.2.3 Alternative 3 – Soil Cover with Buttress Fill

Alternative 3, Soil Cover with a buttress fill is presented in Section 6.1.3 and generally includes the removal of radiologically contaminated surface soil (completed in August 2004), limited site grading, placement of a 2-ft-thick soil cover, revegetation of the soil cover, and installation of a buttress fill at the toe of the regraded slope.

Effectiveness

Effectiveness considers whether the alternative provides protection of human health and the environment, and achieves the remedial objectives.

Protectiveness

Alternative 3 provides the same degree of overall protection as Alternative 2 because the waste would be covered to prevent direct contact. Alternative 3 would comply with ARARs. Construction of the buttress fill would only slightly add additional long-term protection of the waste fill area by reducing the possibility of movement (see Table 6.1). Potential worker exposure to radioactively and nonradioactively contaminated substances would be higher during implementation of Alternative 3 than during Alternative 2 because of the excavation of soil and possibly the weathered bedrock to allow construction of the buttress.

Alternative 3 would provide a slightly higher level of long-term effectiveness because the stability of the OLF coupled with the stability of an appropriately designed soil cover the buttress would increase slightly. Alternative 3 would rely upon proven technologies for slope stabilization and landfill covering. Although unlikely, plugging

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of the buttress drains could lower the stability of the buttress by saturating the buttress soil and increasing the water levels.

Alternative 3 would have lower short-term effectiveness than Alternative 2. This alternative has a greater chance of impacting workers, the public, and the environment during implementation. Greater potential health impacts would be due to creating more potential inhalation of fugitive dust and the ingestion of dust and contaminated materials (hand to mouth) and the risks associated with construction of the buttress (more heavy equipment and truck traffic). However, health and safety controls would be readily implemented to reduce the risk to workers and the public. In addition, construction of Alternative 3 would remove more jurisdictional and candidate wetlands and PMJM protection area than Alternative 2, and prevent the growth of PMJM habitats up the landfill slope.

Achieve Remedial Objectives

Alternative 3 would meet all of the remedial action objectives. The Landfill would be covered with an appropriately designed soil cover to prevent contact with the waste materials. However, construction activities will permanently remove wetlands and a portion of the PMJM protection area within the boundary of the OLF.

<u>Implementability</u>

Implementability addresses the technical and administrative feasibility of implementing an alternative using the required equipment, services, and materials.

Technical Feasibility

Alternative 3 is technically feasible using proven controls and engineering design features that have been successfully implemented at other sites with similar conditions; however, the buttress fill is more difficult to build than the components of Alternative 2. Construction of the buttress may require trench boxes or special shoring to prevent movement of soil and waste materials into the buttress excavation. All controls within the alternative could be executed using readily available machinery, including earthmoving equipment, haul trucks, and other conventional construction equipment.

Alternative 3 would require more maintenance and inspections than Alternative 2 because of the added component buttress fill. Monitoring of groundwater and surface water would be required, just like Alternative 2.

Availability

For Alternative 3 mainly natural materials are required; however, more material will be required than for Alternative 2. The materials would either come from an on-site borrow source, or a borrow source close to the site. Monitoring would use industry standard equipment and materials that are also readily available.

Administrative Feasibility

The implementation of Alternative 3 does not require permits or easements, and does not impact adjoining property. It will not inhibit the ability to impose institutional

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controls. Existing site management and access controls would be maintained until a comprehensive final plan is implemented in the future. The alternative is consistent with the aesthetic qualities of the facility end use as a wildlife refuge; however, the migration of PMJM habitat north of the buttress would be seriously slowed or eliminated.

Alternative 3 would permanently remove jurisdictional wetlands and PMJM protection area.

Alternative 3 would most likely gain CDPHE, EPA, and community acceptance more readily than Alternative 2.

<u>**Cost**</u>

Evaluation of costs should consider the capital costs to engineer, procure and construct the required equipment and facilities, and the operating and maintenance costs associated with the alternative.

Capital Cost

The capital cost to implement Alternative 3 is between $6,000,000 and $6,900,000.

Operation & Maintenance Cost

The operation and maintenance costs associated with this alternative involve inspection and maintenance of the cover. Other monitoring costs, such as groundwater and surface water monitoring would also be included. Operation and maintenance costs are estimated to be $31,000 per year.

Summary – Alternative 3

Alternative 3 does not significantly provide for greater protection of the public and environment than Alternative 2 and exhibits greater short-term and long-term impacts to the ecological environment. Therefore, this alternative is not considered the most cost-effective accelerated action. Alternative 3 increases the risk of worker injury over that of Alternative 2 with the additional construction materials and operation of heavy construction equipment. Alternative 3 was not retained.

6.2.4 Alternative 4 – Removal with Offsite Disposal

Alternative 4, Removal with offsite disposal is presented in 6.1.3 and generally includes the removal of radiologically contaminated surface soil (completed in August 2004), the removal and disposal of all OLF wastes and contaminated soil, and grading of the area to a stable configuration.

<u>**Effectiveness**</u>

Effectiveness considers whether the alternative provides protection of human health and the environment, and achieves the remedial objectives.

Protectiveness

Alternative 4 would provide the highest level of long-term effectiveness, because all waste materials would be removed permanently from the OLF area. Alternative 4 would rely upon proven techniques for waste excavation, classification, and disposal.

Under Alternative 4, material removed from the OLF will require characterization for disposal in an appropriately licensed facility. However, prior to disposal, the waste may need to be treated to meet Land Disposal Restriction (LDR) standards or other standards required by the disposal facility. The types of treatment required would be identified during design and implementation. Alternative 4 would comply with ARARs, although compliance with waste management requirements for treatment and disposal may prove difficult or impractical for some wastes. This could lead to the need for waste storage at RFETS pending final waste disposition.

Alternative 4 will have a high short-term effectiveness due to the exposure of the workers to waste during implementation and the potential for an off-site release due to transportation accidents. This alternative will also temporarily damage jurisdictional and candidate wetlands within the boundary of the OLF. Wetlands and PMJM habitat mitigation may be required.

Achieve Remedial Objectives

Alternative 4 will meet all of the remedial action objectives because all the waste materials would be removed from the site for disposal in off-site licensed facilities. Construction activities will damage jurisdictional wetlands and a portion of the PMJM protection area within the boundary of the OLF. However, these habitats will likely recover.

Implementability

Implementability addresses the technical and administrative feasibility of implementing an alternative using the required equipment, services, and materials.

Technical Feasibility

Alternative 4 is technically feasible using only proven controls that have been successfully implemented at other sites with similar conditions. All controls within the alternative could be executed using readily available machinery including earthmoving equipment, haul trucks, and other conventional construction equipment. However, the handling, segregation, sampling, treatment, and disposal processes for this alternative are technically challenging and will require additional operational and safety procedures for successful implementation.

Off-site disposal included in the alternative would be technically feasible, because disposal facilities have been identified by RFETS and have been used for waste disposal in the past. However, this alternative may require waste storage pending disposition of some wastes at off-site disposal facilities.

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Alternative 4 is the only alternative that does not require post action maintenance or monitoring by RFETS or the USFWS. The commercial disposal facility chosen would be responsible for all monitoring and maintenance of the disposed waste.

Availability

Required goods and services for implementation of the alternative are reasonably available, although treatment may be costly and impractical for some wastes. It is anticipated that the contractors, labor, equipment, and most of the materials would come from the Denver/Front Range area, which surrounds the site.

Off-site disposal facilities are established for hazardous and radioactive waste generated at RFETS. Solid waste would be disposed of in a nearby State-permitted solid waste facility. Off-site RCRA hazardous waste and low-level hazardous waste would be disposed at appropriate facilities (for example, NTS and/or Envirocare of Utah).

Administrative Feasibility

The implementation of Alternative 4 does not require permits or easements, and does not impact adjoining property. It will not inhibit the ability to impose institutional controls. Existing site management and access controls would be maintained until a comprehensive final plan is implemented in the future. The alternative is generally consistent with the aesthetic qualities of the facility end use as a wildlife refuge.

This alternative will temporarily damage jurisdictional wetlands and a portion of the PMJM protection area. Therefore, formal consultation with the USFWS would be required for potential PMJM impacts.

Alternative 4 is administratively feasible; however, is the most complex alternative because all waste will be removed from the OLF area and disposed of off site. Typical safety concerns with the transportation of radioactive and nonradioactive contamination from the site would be expected. However, transportation of similar waste from RFETS is routine and is unlikely to cause public concern. Appropriate safety measures would be implemented to protect the public during waste transportation.

Cost

Evaluation of costs should consider the capital costs to engineer, procure and construct the required equipment and facilities, and the operating and maintenance costs associated with the alternative.

Capital Cost

The capital cost to implement Alternative 4 is between $100,000,000 and $260,000,000 depending on the actual composition of the waste materials and the need for treatment prior to disposal.

Operation & Maintenance Cost

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No operation and maintenance costs would be incurred with this alternative.

Summary – Alternative 4

Alternative 4 was not retained for further consideration because the high costs of removal, treatment and disposal make this alternative impractical. Alternative 2 will meet the remedial action objectives at a lower cost.

6.2.5 Summary

This section discusses the results of the comparative evaluation for each remedial alternative for the OLF at RFETS. The results are also summarized in Table 6-1.

Alternative 1 would not prevent direct contact with the OLF debris or control the current erosional processes. However, it could be easily implemented and would be cost effective, relying wholly on active controls to limit risks. This alternative was not selected as the proposed accelerated action for the OLF.

Alternative 2 will prevent direct contact with the OLF debris and control erosional processes, with a short disruption of the PMJM habitat. The alternative is implementable. This alternative includes post-accelerated action institutional controls to maintain remedy effectiveness, but the controls are not difficult to implement. The primary drawback to Alternative 2 is that it exposes some waste during the slope stabilization process, and creates potential worker safety and environmental issues. This alternative was selected as the proposed accelerated action for the OLF because it is the most cost-effective and it implements the presumptive remedy.

Alternative 3 would prevent direct contact with the OLF debris and control erosional processes, but with permanent disruption of the PMJM habitat and additional wetland removal. The alternative is implementable; however, construction is more difficult and requires more materials and use of heavy construction equipment. This alternative includes post-accelerated action institutional controls to maintain remedy effectiveness, but the controls are not difficult to implement. Alternative 3, like Alternative 2, also exposes some waste during the slope stabilization process.

Alternative 3 does not significantly provide for greater protection of the public and environment than Alternative 2 and exhibits greater short- and long-term impacts to the ecological environment. Therefore, it is not considered the most cost-effective accelerated action. Alternative 3 would increase the risk of worker injury over that of Alternative 2 with the additional construction materials and heavy construction equipment. Alternative 3 was not selected as the proposed accelerated action for the OLF.

Alternative 4 provides the highest level of protection for public health and the environment with a short disruption of the PMJM habitat. However, it presents the highest risk to workers implementing the action. It is also extremely expensive due to the high cost of off-site disposal in licensed facilities. Because of the high cost and long construction duration, this alternative was not selected as the proposed accelerated action for the OLF.

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7.0 PROPOSED REMEDIAL ACTION PLAN

The remedial action plan for the OLF will consist of the following major activities to meet the RAOs:

- Removal of surface soil "hot spots" (removal completed, see Appendix C);
- Limited grading of landfill to slope of 18 percent;
- Placement of a 2-ft-thick soil cover over the entire fill area;
- Engineering controls;
- Site monitoring (groundwater and surface water); and
- Institutional controls.

The objectives of this action are principally met through the removal of surface soils that are contaminated above the soil action level and installation of the landfill soil cover. However, additional continuing actions are required to maintain and assess the protectiveness and effectiveness of the cover. Further discussion of the actions in relation to attaining to the extent practicable, ARARs is contained in Section 8.0. Further discussion of Long-Term Stewardship activities is contained in Section 10.0.

These actions will be taken until final remedy requirements are selected and incorporated (along with post-closure requirements for remedial actions conducted at other IHSSs at Rocky Flats) in post-closure regulatory documents, which may include the final CAD/ROD for Rocky Flats or a post-closure RFCA-type agreement.

7.1 Removal of Surface Soil Hot Spots

Surface soil with concentrations above the WRW and Ecological Receptor action levels were removed as shown on Figure 4-2. A description of the removal and confirmation sampling results are presented in Appendix C.

7.2 Area Grading & Soil Cover

The waste fill area will be graded to generally an approximately 18-percent (5.5:1) slope using a cut-and-fill approach that will be as balanced as possible (See Figures 6-1 and 6-2). Standard earth-moving equipment, such as dozers, hoes or scrapers, will be used to cut the areas where the slope exceeds the desired 18 percent and to fill the areas where the slope is less than the desired 18 percent slope. It is estimated that approximately 55,000 cubic yards of waste fill material will be moved during the process and 105,000 cy of fill will be required to reach the 18-percent grade before placing the 2-ft cover.. The grading plan will be optimized in the design to add stormwater drainage swales, and run-on and runoff controls, as well as balance the overall cut/fill earthmoving yardages and include anticipated groundwater elevations and bedrock topography.

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Control measures will be implemented during the grading process to control the spread and release of waste materials in the OLF. The control measures will include establishment of work zones, decontamination procedures, dust suppression methods, traction mats, visual inspections, and radiological surveys. Work will be suspended when environmental conditions could greatly increase the possibility of the spread of contaminated materials. Monitoring will be performed, as necessary, to verify that there has been no release of contaminated materials. Generally, the work will be conducted as if at a radiologically contaminated site using proper personal protective equipment (PPE), respiratory protection, and worker monitoring.

After grading of the landfill surface is complete, a soil cover will be placed over the landfill to a minimum thickness of 2 ft. Approximately 65,000 cubic yards of local or onsite soil will be used to construct the cover. The soil cover will be sufficiently compacted to provide a stable cover system to promote surface water runoff, reduce surface water ponding, increase overall slope stability, and provide a suitable soil surface for revegetation.

Revegetation of the soil cover with native species will reduce infiltration and control erosion. This approach is in keeping with the current strategy to restore RFETS with the native prairie grasslands as closely as possible. The seeding will be conducted, along with using erosion control matting or mulch, to prevent erosion of the cover while allowing the vegetation to establish a strong stand.

The following plant properties will ensure healthy, productive, and long-term vegetative growth on the landfill cover:

- Locally-adapted, noninvasive or native species able to withstand Front Range drought and temperature extremes will be used as vegetative cover.

- Long-term fertilization and nutrient supplements are not planned at this time; therefore, it is critical that the vegetation be able to survive under existing soil conditions. Native grasses and forbs will thrive with little maintenance. Soil amendments may be provided to supplement borrow material to establish initial vegetation on the cover.

- Both cool and warm season species will be planted to provide transpiration throughout as much of the year as possible. Locally-adapted species of grasses and forbs normally transpire all available water in semiarid climates, such as that at RFETS.

- A strong stand of vegetation will limit cover erosion from both wind and water.

A draft seed mix will be developed during the design in consultation with the RFCA Parties, the RFETS Ecology Group, and other interested parties.

7.3 Engineering Controls

Engineering controls may be used to provide a physical barrier to protect the public and wildlife refuge workers from potential risks at the site. The engineering controls may include signage to limit public access. Signs to inform the public of limited access would be posted at 200-ft intervals.

7.4 Site Monitoring

Site monitoring will include a program to ensure that current conditions at the site do not change in an adverse manner. Surface water and groundwater monitoring will be instituted to identify impacts after the action has been implemented. An annual walkdown of the area will be conducted to identify areas of erosion of the soil cover for repair. A ground survey will also be completed to monitor slope stability. More details regarding site monitoring is presented in Section 10.0. Monitoring locations will be determined during the design of the accelerated action.

7.5 Institutional Controls

General and specific post-accelerated action institutional controls for RFETS as a whole are currently being evaluated by DOE and the regulatory agencies, and in consultation with the USFWS and the community.

The controls that will be implemented at the OLF for this proposed action are as follows:

1. Current Site-wide security and access controls will be maintained until completion of the RFETS Closure Project, currently scheduled for December 2006, but will be replaced by equivalent controls for the OLF and other specific areas for which security and access controls are required.

2. In accordance with the Rocky Flats Wildlife Refuge Act of 2001 (Pub.L. 107-107, Sec. 3171-3182 [December 28, 2001]), DOE will retain jurisdiction over the engineered controls associated with the proposed action.

3. Drilling and pumping of groundwater wells for uses other than the remedy.

4. Use and excavation of the cover and the area in the immediate vicinity of the cover will be prohibited

5. Drilling on and in the immediate vicinity of the cover will be prohibited.

6. Disruption of surface water sampling stations until such stations are no longer needed will be prohibited.

7. To avoid adverse impacts, roads and trails will not be allowed on the cover or the immediate vicinity of the cover. Signs may be erected that indicate vehicles are prohibited from specific areas and that direct vehicle traffic appropriately. A determination will be made during project construction as to whether signs or barriers will be used as the preferred means of restricting access.

8. Upon construction completion, fencing at specific locations on or around the cover, will also be considered to limit the potential for damage or tampering with the Site. Signs and markers may be used as controls to delineate the landfill boundary; outline digging, fishing, swimming, groundwater, and surface use restrictions; and/or describe access restrictions to the landfill cover and monitoring locations for the cover.

Final institutional and physical controls for the accelerated action will also be documented in the Closeout Report. Inspection of these institutional controls will be performed quarterly to determine their continuing effectiveness. Results of these inspections will be reported annually.

7.6 Worker Health and Safety

All work under this proposed action will be controlled using the Site Integrated Safety Management System (ISMS) and the Integrated Work Control Program (IWCP). A project-specific HASP will be developed to address the safety and health hazards of project execution and specify the requirements and procedures for employee protection. The Occupational Safety and Health Administration (OSHA) construction standard for Hazardous Waste Operations and Emergency Response, 29 Code of Federal Regulations (CFR) 1926.65, will be used as the basis for the HASP. In addition, DOE Order 5480.9A, Construction Project Safety and Health Management, applies to this project. This Order requires preparation of an Activity Hazard Analyses (AHA) for each task, which includes identifying the task, hazards associated with the task, and controls necessary to eliminate or mitigate the hazards. The AHAs will be included in the HASP.

Data and controls will be continually evaluated. If field conditions vary from the planned approach (for example, when unanticipated hazards are encountered, such as contaminated debris and airborne contamination), an AHA will be prepared for the new conditions, and work will proceed according to the appropriate control measures.

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8.0 APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS

As required by Part 4 of RFCA, the proposed action will be performed to the extent practicable in compliance with applicable or relevant and appropriate requirements (ARARs) under CERCLA. ARARs have been identified for the proposed action consistent with the NCP, the preambles to the proposed and final NCP, and CERCLA Compliance with Other Laws Manuals Part I and Part II (EPA 1988, 1989).

The ARARs are presented in Appendix A. This section provides additional detail for the ARARs related to the cover for the OLF, post-closure care, air, surface water, wetlands, wildlife and mineral resources.

As discussed in Section 4.0, the OLF has not impacted the environmental media outside the landfill boundary (surface water and groundwater) since its closure 36 years ago in 1968. The actions outlined in this IM/IRA will be designed to increase the protectiveness of the OLF. Specifically, the soil cover will be designed and built to perform the following functions:

- Prevent direct contact with the fill materials and commingled soil;
- Reduce and control the erosion of surface soil;
- Provide a separation layer between surface water runoff and the fill materials and contaminated soils;
- Reduce the infiltration of groundwater through the fill material by providing a continuous soil cover and positive drainage of stormwater flow off the cover;
- Provide for minimal impact to PMJM habitats; and
- Maintain or enhance stability characteristics of the OLF to minimize adverse impacts from potential future landsliding.

8.1 Landfill Cover Requirements

The proposed containment accelerated action for the OLF includes a cover that will be designed and constructed to meet any Relevant and Appropriate requirements (ARARs) of the cover performance standards in 40 CFR Part 265.310(a). This section focuses only on those 265.310(a) requirements that have been determined to be both relevant and appropriate to the OLF.

Specifically, the cover performance standards determined to be relevant and appropriate are 40 CFR 265.310(a)(2) and (a)(4), which require DOE to close the landfill with a final cover designed and constructed to:

- Function with minimum maintenance; and

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- Accommodate settling and subsidence so that the cover's integrity is maintained.

To demonstrate compliance with these cover performance standards, the following sections discuss each of these requirements.

Ancillary activities performed concurrently with construction of a stable soil cover will include PMJM habitat protection, wetlands protection, surface water management, and site security. Compensatory mitigation for unavoidable impacts to wetlands will be provided in accordance with ARARs. Grading the surface of the landfill will control surface water runoff. Surface water will drain south and into Woman Creek.

Site security will be maintained during and after construction activities. Signs will be posted warning of potential danger at the landfill.

8.1.1 Function With Minimum Maintenance

Based on the evaluation of all the environmental and geotechnical data, the current soil cover and contour of the placed waste and commingled soil at the OLF do not present a significant hazard after over 36 years in this configuration. Implementation of the proposed accelerated action will further minimize landfill maintenance in the following areas:

- The regraded surface and 2-ft-thick cover will reduce cover maintenance by providing several ft of separation between the waste and surface of the landfill (prevent direct contact with the waste), by eliminating the erosion and sloughing of soils that have resulted from poor waste placement practices, and providing a more geotechnically stable landfill.

- Stormwater runon controls will divert surface water away from the OLF to reduce stormwater erosion.

- Stormwater runoff will be controlled by the grading/contouring of the landfill surface to eliminate ponding water and promote positive drainage from the landfill.

- The soil cover of the landfill will be vegetated to reduce surface erosion. This will also increase landfill stability by reducing groundwater levels through plant evapotranspiration.

8.1.2 Accommodate Settling and Subsidence to Maintain Cover's Integrity

Because the OLF has been inactive for 36 years, settling and subsidence are considered complete. However, to prevent any further movement, the following observations are noted:

- The waste is currently commingled with soil (over 50 percent), which reduces the extent of settling and subsidence.

- The proposed accelerated action will reposition and recompact some of the waste and commingled soil to further reduce settling and subsidence.

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- Appropriate method compaction specifications will be developed to provide the appropriate levels of compaction to reduce settling and subsidence.

- Furthermore, a soil cover is very flexible with regard to settling and subsidence and also extremely easy to repair should the need arise.

8.2 Air

The proposed action has the potential to generate fugitive particulate emissions, but very little potential for hazardous air pollutant emissions. Subpart H of 40 CFR Part 61 contains the requirements for monitoring and reporting activities within DOE facilities that have the potential to emit radionuclides other than radon. Potential emissions from the proposed action that may affect 40 CFR 61 compliance have not been identified; however, normal perimeter National Emission Standards for Hazardous Air Pollutants (NESHAPs) compliance air monitoring will be conducted during the cover installation.

Colorado Regulation No. 1 (5 CCR 1001-3) governs opacity and particulate emissions. Section II of Regulation No. 1 addresses opacity and prohibits stack emissions from fuel-fired equipment exceeding 20 percent opacity. Section III addresses the control of particulate emissions. Fugitive particulate emissions will be generated from construction and transportation activities. During construction activities, dust minimization techniques, such as water sprays, will be used to minimize suspension of particulates. In addition, construction activities will not be conducted during periods of high wind. The substantive requirements of Regulation No. 1 will be incorporated into a Dust Control Plan, which will define the level of particulate control for the project.

Colorado Regulation No. 3 (5 CCR 1001-5) provides CDPHE with the authority to inventory emissions, and Part A describes Air Pollutant Emission Notice (APEN) requirements. Air quality management subject matter experts will evaluate the project emissions and, if applicable, an APEN will be prepared to facilitate CDPHE's inventory process.

The final surface of the landfill cover will appropriately reduce the potential post-accelerated action wind erosion of soil and subsequent particulate emissions. Significant air emissions are not anticipated after the closure construction is complete.

8.3 Surface Water

The proposed action has the potential to impact surface water during construction. As described in the following paragraphs, impacts will be minimized by meeting the substantive requirements of the Clean Water Act and associated implementing regulations.

8.3.1 Stormwater

Given the expected conditions at the OLF site, no significant surface water impacts are anticipated as a result of stormwater events. However, because the total area of the project is greater than 1 acre and the location is outside the IA, which has an effective National Pollutant Discharge Elimination System (NPDES) Permit for Storm Water, the proposed action would require an NPDES Storm Water Permit for Construction Activities, except for

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the fact that it is a CERCLA action, Paragraphs 16 and 17 of RFCA, establish the requirements under which a CERCLA permit waiver applies. For any action that would require a permit except for CERCLA, Paragraph 17 requires that certain information be included in the submittal.

Permit Required

Because the landfill cover construction project is greater than 1 acres in size and lies outside of the Site's IA, an NPDES General Storm Water Permit for Construction Activities would be required. The permit is found at 40 CFR Part 122, and is obtained by filing a Notification of Intent (NOI) with EPA. This IM/IRA serves as the NOI for the OLF.

Requirements to Obtain a Permit

Because the stormwater permit for construction activities is a general permit, it has been through public comment and promulgated by EPA. Obtaining the permit was done through the NOI (that is, a letter submittal to the agency containing basic information about the project). The permit requires installation of best management practices (BMPs) and structural stormwater controls, such as silt fences, to protect downstream waters from potential surface water contaminants (for example, sediment-laden runoff). These requirements will be part of the cover design.

How Stormwater Control Measures Meet the Requirements

The total area of disturbed soil is approximately 22 acres, including the area of the landfill to be resurfaced (20 acres) and miscellaneous construction activities (2 acres). Surface water control measures will be used to minimize surface water contact with potentially contaminated soil or groundwater and minimize erosional effects during the construction activities. Precipitation falling on areas where construction is in progress will be diverted to existing surface water drainage ditches. Other shallow ditches will be temporarily constructed as needed to prevent sediment-laden stormwater from flowing directly into Woman Creek. Newly-constructed soil surfaces will be stabilized using soil terracing, revegetation hydromulch, straw-mulch, silt fencing, straw waddles, and other stormwater BMPs to minimize soil erosion, sediment transport, and surface water quality degradation until the required vegetation is established. The use of straw-mulch, straw waddles, adequately spaced silt fences, and other appropriate measures minimizes soil loss and allows the vegetation to become established.

8.3.2 Remediation Wastewater

Remediation wastewater generated during construction activities is not expected; however, if produced, it will be managed consistent with provisions of the RFCA Implementation Guidance Document (IGD) (DOE et al. 1999). Remediation wastewater, if produced, will be collected, characterized, and treated on or off site if required, directly discharged in accordance with requirements of the Site's Incidental Waters Program (K-H 2003a).

8.4 Wetlands

As described in Section 3.8, the U.S. Army Corps of Engineers has designated wetlands within the construction area. DOE will mitigate the permanent loss of wetlands resulting

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from the remediation construction in accordance with a Wetland Mitigation Plan to be prepared as part of the remedial action design (see Appendix E).

8.5 Wildlife

Construction activities will remove jurisdictional wetlands and a portion of the PMJM protection area within the boundary of the OLF. Formal consultation with USFWS will be required. Wetland and PMJM habitat mitigation may be required. However, disruption of the PMJM habitat is temporary. Mitigation plans will be developed during design of the action, as required.

Construction activities may impact migratory birds protected by the Migratory Bird Treaty Act. Due to the variations in potential impacts depending upon the season and nesting schedules for migratory birds, the substantive requirements of these federal statutes will be evaluated by the Site Ecology Group prior to conducting activities associated with the proposed action. The substantive requirements identified during the evaluation will be implemented throughout the construction process.

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9.0 ENVIRONMENTAL IMPACTS

Paragraph 95 of RFCA mandates incorporation of National Environmental Policy Act (NEPA) values into RFETS decision documents. This section of the IM/IRA satisfies the RFCA requirement for a "NEPA equivalency" assessment of environmental consequences by addressing the environmental consequences of the proposed accelerated action.

The remediation impact analysis relies heavily on conclusions reached in the Cumulative Impact Document (CID) (DOE 1997) and the 2000 CID Update Report (DOE 2001), both of which focus on cumulative impacts resulting from on-site closure activities. In general, the proposed action will have very few adverse short-term impacts on a variety of resource areas, including air quality, water quality, traffic congestion, and ecological resources. In some instances, the impacts could be intense for a short period of time. However, the impacts will not notably affect human health and safety, or the environment, and they will be temporary and controlled through mitigation actions (for example, dust will be controlled with water sprays during placement of the cover).

The proposed action will have both positive and adverse effects, each identified in this section. Certain mitigation measures are required by law and are also identified for each resource area.

9.1 Impacts to Air Quality

The purpose of this section is to assess the potential impacts to air quality associated with implementation of the proposed accelerated action (regraded surface with soil cover), including fugitive dust emissions and methane emissions.

9.1.1 Potential Fugitive Dust Emissions

The primary pollutant generated as a result of the proposed action will be fugitive dust, which includes total suspended particulates (TSP) and particulate matter 10 micron (PM_{10}), and particulate matter 2.5 microns ($PM_{2.5}$) in size. Dust emissions from the regrading and cover construction activities will be controlled with practical, economically reasonable, and technologically feasible work practices, as required by the CAQCC Regulation No. 1. Specifically, on-site dust will be controlled through dust minimization techniques, such as the use of water sprays to minimize suspension of particulates, and terminating earthmoving operations during periods of high wind. In addition, PM10 will be monitored consistent with the Site IMP (RFETS 2000). Particulate emissions will be short-term and controllable, and emissions are not expected to be above enforceable National Ambient Air Quality Standards (NAAQSs) at the RFETS perimeter. Therefore, potential impacts to workers and the public from proposed action will not be significant.

9.1.2 Potential Equipment Emissions

The regrading and cover construction activities will also include operation of vehicles, heavy machinery, and other equipment that generate other criteria pollutants. Estimated concentrations of other criteria and Hazardous Air Pollutants provided in the CID (DOE 1997)

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were well below the most restrictive occupational exposure limit, with the exceptions of sulfur dioxide, nitrogen dioxide, and carbon monoxide, which approached 50 percent of the most restrictive occupational exposure limit. The CID (DOE 1997) identified the primary sources of these pollutants as diesel-powered emergency generators used to supply backup power at RFETS. According to the 2000 CID Update Report (DOE 2001), maximum daily emissions will remain about the same as forecast in the CID (DOE 1997). Equipment emissions from construction activities at the OLF are expected to be substantially less than the CID (DOE 1997) and 2000 CID Update Report (DOE 2001) estimates; therefore, impacts to workers and the public are not a concern.

9.2 Impacts to Surface Water

Construction activities at the OLF will result in surface disturbance from the clearing of vegetation, excavation and salvage of topsoil material, blading and leveling of the land, the potential for accidental uncovering of contaminated media, and the construction of the soil cover. Potential impacts to surface water during the construction phase include increased erosion, and subsequent sediment loading to drainage ditches and Woman Creek during storm events. The absence of vegetative cover results in increased potential for both sheet and channelized runoff, as well as wind and water erosion, resulting in increased sedimentation of ditches and Woman Creek.

The soil cover construction will require soil obtained from off-site commercial operations or on-site sources. Excavation of these borrow materials has impacts similar to those identified above. Off-site facilities address these issues through permits issued to the facility.

The construction activities are expected to result in limited physical contact with contaminated soils or waste materials. In the event equipment and personnel come in contact with potentially contaminated materials during construction, decontamination will be performed at the RFETS main decontamination facility or a temporary decontamination facility at the OLF to reduce potential impacts to surface water.

Long-term impacts will remain minimal because the regrading, soil cover, and revegetation will minimize infiltration of precipitation and subsequent contact with contaminants. The proposed accelerated action will also incorporate surface drainage features to control runon/runoff and provide surface erosion control. The proposed action will result in a decrease in the risk of contaminants reaching surface water by:

- Preventing direct contact of precipitation with the waste materials and commingled soil;
- Providing Stormwater runon and runoff controls; and
- Preventing soil erosion by providing temporary, engineered erosion controls and cover revegetation.

Precipitation falling within the boundary of the landfill will be drained from the cover and diverted away from the landfill. Surface water drainage from areas outside the OLF boundary

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will be prevented from flowing onto the landfill and diverted around the boundary. Using appropriate surface-reclamation measures, adequate vegetative cover will be established on the final surface of the landfill. The establishment of vegetative cover on the new slopes and contours of the landfill, and the surrounding disturbed surfaces, will greatly reduce erosional hazards to levels similar to surrounding areas.

Post-accelerated action monitoring activities will include inspections of the landfill surface and associated drainage ditch conditions. Observations of the vegetative cover and evidence of soil erosion and loss will be included in the routine inspection and maintenance activities. Further erosion control measures, regrading, and revegetation will be implemented if maintenance inspections indicate the landfill surface erosion controls are not as effective as planned.

The SID in the area of the OLF will be eliminated by implementing the proposed action. The SID will be effectively replaced with installation of the soil cover. Removal of the SID will enhance the overall stability of the landfill by eliminating the existing ponding of stormwater on the OLF.

9.3 Impacts to Groundwater

Groundwater quality in the area of the OLF is not significantly impacted. The intended purpose of the cover is to prevent contact with potentially contaminated landfill material. The regraded cover will also reduce surface water from percolating through the landfill to groundwater. These measures will prevent localized contamination of groundwater. The regraded soil cover will provide an overall positive impact to groundwater and will continue to protect groundwater quality at the site. No significant negative impact to groundwater quality is expected from implementation of the accelerated action.

9.4 Impacts to Wildlife and Vegetation

The OLF construction activities will have varying impacts on ecological resources within the project area. Impacts to ecological resources are unavoidable; however, adverse impacts will be minimized through mitigative measures. The Proposed Action will principally affect wetlands, migratory bird habitat, and habitat for the PMJM (*Zapus hudsonius preble*), a federally-listed threatened species under the Endangered Species Act. Impacts to the PMJM and wetlands may require mitigation (that is, a replacement of habitat of equal value either on or offsite). Habitat for native animals will change slightly, as the hillside is regraded and revegetated during construction of the proposed accelerated action. However, the changes will improve the quality of the vegetation by replacing exotic species with native species. The changes will adversely affect some species for a short time, but will likely have a long-term benefit for most endemic species.

Because the PMJM is a federally-listed threatened species, its habitat is a primary concern at RFETS. Several acres of PMJM habitat are located on RFETS. The PMJM is found in the riparian woodland/shrubland habitat along Woman Creek, and designated PMJM habitat extends into the southern portion of the OLF area as shown on Figure 3-4. Some designated PMJM habitat will be lost permanently within the project area because of soil cover (landfill

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cap) constraints. However, some of PMJM habitat will be only temporarily impacted by the project. Both temporary and permanent impacts will be mitigated through consultation with the USFWS.

Other animal species will lose existing habitat when the construction of accelerated action is completed. The regraded soil cover may limit the types of animals that eventually occupy the area. The changes, however, will benefit yet other species. Many endemic species are adapted to prairie environments and would readily inhabit the reconfigured OLF.

Migratory birds are protected under the Migratory Bird Treaty Act. Both the birds and their nests are protected under this law. Songbirds occasionally nest in the trees and shrubs or on the ground in the OLF area. Active nests will be protected; inactive nests will be removed prior to construction activities, through the use of special permits from the USFWS. While long-term habitat changes that result from the proposed action will adversely affect some bird species (for example, loss of a nesting site for owls), other species (for example, grassland species) will benefit from the changes.

Much of the OLF project area is currently dominated by noxious weed species, such as diffuse knapweed and scotch thistle. These weeds have invaded the disturbed ground within the project area over the past decade. Additionally, non-native species of grasses, such as smooth brome and intermediate wheatgrass, were planted along the SID after it was constructed. These non-native species will be replaced with native species that provide better wildlife forage and habitat, and increase the natural resource values of the area.

There are several small wetland areas within the boundary of the OLF project area that will be destroyed. The impacted areas are subdivided as follows:

- SID Wetlands: The entire SID wetland area is 3.06 acres; the portion of the SID that will be affected by the proposed action is 0.34 acres.
- Woman Creek Wetlands: The proposed accelerated action is not expected to impact the wetlands in Woman Creek.
- Candidate Wetlands: Eight small isolated areas identified as potential wetlands, totaling approximately 0.91 acres, are located north of the SID. Designation of these areas as "jurisdictional" is currently in discussion.

A conceptual approach to mitigating wetland damage at the OLF is being developed. The approach to offset wetland losses is based on a worst-case scenario, wherein all wetlands on the hillsides and along Woman Creek are impacted. A Wetlands Mitigation Plan will be prepared that describes the actions that will be taken to replace wetlands that are destroyed. Both in-situ wetland creation/restoration and the use of wetland bank credits have been proposed for mitigation of wetland impacts. The use of either technique or a combination of the techniques is subject to review and approval by the USFWS. The mitigative measures are therefore considered sufficient to offset losses and other adverse impacts to wetlands.

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The OLF project may temporarily affect water quality from eroded soil during construction. Erosion controls will be used to minimize water quality effects. Surface water flow volumes may change due to the design of the new landfill cover. Such changes would be minimal and would occur sporadically (for example, after heavy rains). The minor potential changes in surface water flow volumes will not change or affect lower Platte River species that depend on instream flows.

Soil materials will be obtained from off-site commercial operations for fill and cover operations, and the excavation of borrow materials will impact wildlife and vegetation at those locations. Commercial facilities must comply with the Endangered Species Act, and threatened and endangered species are therefore protected. The impact to other species will vary but will depend on the facility and extent of the operations. However, these indirect impacts are considered in operational permits issued for the facilities by state and local county governments.

9.5 Impacts to Nearby Populations

In accordance with Executive Order 12898, the potential impact of the proposed action on minority and low-income populations is considered. The proposed action will occur on site away from inhabited areas, and will not lead to off-site indirect effects on nearby populations. Disproportionately high and adverse human health or environmental effects will not be imposed on these populations. The proposed action will provide short-term employment for a limited number of people, and socioeconomic effects of the action will be minimal.

9.6 Impacts to Transportation

The proposed accelerated action will only slightly impact both on-site and off-site transportation systems. Increased on-site truck traffic will be an inconvenience; however, safety risks will be low, and impacts will be mitigated by very low and closely observed speed limits. In comparison analyses in the CID (DOE 1997; 2001), off-site traffic impacts will not increase substantially.

9.7 Impacts to Cultural and Historic Resources

RFETS was placed on the National Register of Historic Places as a Historic District (5JF1227) on May 19, 1997. Historic District designation mandates compliance with the Historic Preservation Act of 1966, and the Programmatic Agreement among DOE, the Colorado State Historic Preservation Officer, and the Advisory Council on Historic Preservation Regarding Historic Properties at RFETS. Although the action will be conducted within the Historic District boundaries, no impact is expected to occur to protected structures.

9.8 Impacts to Visual Resources

During installation of the cover, bulldozers and other equipment may be visible from off-site locations. Dust generated during earthmoving operations may be temporarily visible, but will dissipate before leaving the Site as a visible cloud or plume of dust. Control measures, such as watering, will be used if needed to control dust.

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9.9 Noise Impacts

Noise levels may be elevated during construction of the accelerated action. Noise levels will not exceed those commonly encountered at a highway construction site. Appropriate hearing protection will be supplied to project personnel as identified in the project-specific HASP.

9.10 Cumulative Impacts

The proposed action supports the overall mission to clean up RFETS and make it safe for future uses. The cumulative effects of this broad, Sitewide effort are presented in the CID (DOE 1997) and 2000 CID Update Report (DOE 2001), which describe the short- and long-term effects from the overall cleanup mission.

The primary focus of the CID (DOE 1997) is cumulative impacts resulting from on-site activities conducted during Site closure. Cumulative impacts result from the effects of Site closure activities and other actions taken during the same time in the same geographic area, including off-site activities, regardless of what agency or person undertakes such other actions. The analysis contained in the 2000 CID Update Report (DOE 2001) included updated on-site and off-site transportation activities, as well as several new off-site activities, although the future non-DOE projects are relatively uncertain. Increased traffic congestion will be the most noticeable impact according to the 2000 CID Update Report (DOE 2001), resulting from increased RFETS traffic and other planned or proposed construction projects near RFETS. Air pollutants and noise will also have adverse impacts; however, the impacts are expected to be short-term in nature, with staggered project start and completion dates. Most people will perceive a positive, long-term visual and "quality of life" benefit, as RFETS infrastructure and equipment are removed, returning RFETS to a more natural appearance.

The cumulative impacts of the proposed action are expected to be similar to those analyzed in the CID (DOE 1997) and 2000 CID Update Report (DOE 2001). Over the short term, additional construction personnel will have an additive effect on the existing workload for Site operations, and there will be increased air emissions, visual impacts, noise, and traffic impacts resulting from construction activities. These short-term impacts will be minimal. Long-term impacts (that is, OLF cover construction activities in conjunction with other environmental restoration work and facility decommissioning activities) facilitate future use of the Site and fulfill the mandated cleanup objectives.

9.11 Irreversible & Irretrievable Commitment of Resources

The proposed action will result in a variety of permanent commitments of resources; however, it is not expected to result in a substantial loss of valuable resources. Most of the resources used for construction of the accelerated action will be permanently committed to the implementation. Irreversible and irretrievable resources are defined as resources that are either consumed, committed, or lost. At the OLF, irreversible and irretrievable resources include the following:

- Consumptive use of geological resources (for example, quarried rock, clay, sand, and gravel for road construction) will be required for construction activities. Supplies of

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these materials will be provided either by on-site or off-site commercial borrow source. The proposed action requires a permanent commitment of fill, soil, and vegetative cover to construct the OLF cover. Adequate supplies are available without affecting local demand for these products.

- Fuel consumed by construction equipment and vehicles used for the construction of the OLF cover will not be recovered.

- Soil in the vicinity of the OLF will be disturbed by construction activities. Many impacts are temporary, pending completion of accelerated action activities and associated revegetation.

- The commitment of up to 25 acres of land as a landfill permanently commits and constrains the area to limited land-use options.

- Wetlands and associated natural resources will be reduced at the OLF. Long-term direct impacts to the floodplain resulting in changes of flood elevations will not occur.

- A long-term commitment of personnel and funds will be required to perform post-accelerated action inspection, maintenance, and monitoring activities.

- Commercial, industrial, and residential land uses are permanently prohibited within boundaries of the OLF due to construction of the cover and the network of monitoring wells.

- Incidental resources that are consumed, committed, or lost on a temporary and/or partial basis during construction include construction personnel and equipment, the construction water source, and construction materials for staging and access.

- Appropriate landfill surface revegetation will result in an acceptable appearance of the site, and the ecological succession of the closed landfill and adjacent land will be improved by surface revegetation. Vegetation and habitat will eventually become similar to surrounding areas.

- Monitoring and maintenance activities will be performed, as necessary, to ensure long-term protection of human health and the environment.

10.0 ADDITIONAL LONG-TERM STEWARDSHIP CONSIDERATIONS

The objective of this section is to identify additional accelerated action care (that is, long-term stewardship) requirements of the proposed accelerated action for the OLF. These requirements are necessary for the long-term effectiveness of this action and include the following components: information management, periodic review, and maintenance of a responsible controlling authority. Other requirements necessary for the short- and long-term effectiveness of the remedy are identified in this IM/IRA, including institutional controls, inspection and maintenance, and environmental monitoring. These requirements are specific to the accelerated actions described in this IM/IRA and are summarized in Table 10-1. Additionally, these requirements will ultimately be captured (along with post-closure care requirements from other accelerated actions at Rocky Flats) in post-closure regulatory documents, which may include the Final CAD/ROD for Rocky Flats or a post-closure RFCA-type agreement.

10.1 Information Management

A successful stewardship program is dependent on retaining the necessary records about the history and residual contamination of the site. Retained information should include the history of the site, environmental data, selected remedies, use of controls and their associated monitoring and maintenance records, and any other information judged necessary for succeeding generations to understand the nature and extent of the residual contamination. At a minimum, the following records will be retained, stored, and retrievable for this accelerated action:

- This IM/IRA and any future modifications;
- The final design for the regraded surface and soil cover and field change requests;
- The as-built drawings of the accelerated action;
- The monitoring and maintenance manual and subsequent revisions;
- Inspection records and logbooks;
- Maintenance records and logbooks;
- Annual performance assessment reports;
- Analytical Data;
- CERCLA 5-year review reports;
- Correspondence involving the regulatory agencies associated with modifications to the post-accelerated action care regime;

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- The Memorandum of Understanding (MOU) between DOE and the U.S. Department of Interior (DOI) (identifying the controlling authority;
- The CAD/ROD; and
- The RFETS HRR and other relevant historical documentation.

This information will be maintained in the Administrative Record (AR) File. Currently, the AR File is maintained onsite. DOE is currently looking at options for retention of permanent records following Site closure.

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Table 10.1
Summary of OLF Post-Accelerated Action Monitoring, Maintenance, and Institutional Control Requirements

Area	Action	Frequency of Action	Criteria	Possible Follow-on Action
Cover	Visual Inspection	Quarterly for five years	Differential Settling/Subsidence	Repair, as necessary.
			Erosion	Repair erosion areas with soil and rock, as necessary.
			Unwanted Vegetation	Remove deep rooting trees or employ weed control measures, as necessary.
			Burrowing animals	Remove and repair damage, as necessary.
Perimeter Drainage Ditches	Visual Inspection	Quarterly for five years	Erosion	Repair erosion areas with soil, erosion blankets and reseeding, as necessary.
			Unwanted Vegetation	Remove deep rooting trees or employ weed control measures, as necessary.
Surface Water Sampling Stations	Sampling	Quarterly for five years	Analyze for VOCs and metals (including uranium). Effluent limitations are the surface water standards. (RFCA Attachment 5, Table 1)	If a surface water standard is exceeded, sampling will increase to monthly for three consecutive months. If exceedances continue, the RFCA Parties will consult to determine whether a change in the remedy is required; additional parameters need to be analyzed; or if a different sampling frequency is required.
Groundwater	Sampling	Quarterly for five years	Increasing trend in VOCs and metals (including uranium) in downgradient versus upgradient groundwater monitoring wells.	Statistically significant changes in downgradient versus upgradient groundwater quality will require consultation between the RFCA parties to determine if changes to the remedy are required.
Institutional and Physical Controls	Visual Inspection	Quarterly for five years	Security and Access Controls; and overall site conditions	Check signs, fences (if required), markers, and overall condition of the OLF site to determine continuing effectiveness of institutional and physical controls.

10.2 Periodic Assessments

Periodic assessments are performed to determine whether the selected remedies and stewardship controls continue to operate as designed, and ascertain whether new technologies might exist to eliminate remaining residual contamination in a safe and cost-effective manner. The CERCLA 5-year review process is required for all Superfund sites that leave residual contamination behind after closure, and establishes the minimum requirements for post-closure periodic assessments. The EPA Comprehensive Five-Year Review Guidance (2001) describes the format of the review and suggests mechanisms that can be implemented through the 5-year review process to ensure the protectiveness of the remedy.

DOE is responsible for conducting the five-year reviews. EPA then issues a finding of concurrence or nonconcurrence. The public has indicated an interest in performing reviews more frequently than the 5-year interval specified in CERCLA. DOE intends to work with its stakeholders to arrive at a review regimen that meets community needs.

The periodic assessment will include actions such as evaluating monitoring and maintenance records, verifying regulatory compliance, and determining whether land use assumptions are still valid. Specific topics for the periodic assessment for the OLF are likely to include cover performance, landfill stability, surface water quality, and groundwater quality; as well as the need to continue monitoring.

10.3 Controlling Authority

Long-term protection of human health and the environment necessitates that a controlling authority be established with responsibility for post-closure management. CERCLA mandates that DOE, as a responsible party, will retain responsibility for the contamination at RFETS resulting from its activities there, as well as responsibility for long-term maintenance of any remedies. The Rocky Flats National Wildlife Refuge Act of 2001 requires that, following certification by EPA, certain lands of the current Site will be transferred from the Secretary of Energy to the Secretary of the Interior. These lands will be under administrative jurisdiction of the USFWS. The Act also requires the Secretary of Energy to retain administrative jurisdiction over Site lands required to carry out response actions required for the cleanup and closure of the Site. The MOU currently being negotiated between DOE and DOI will outline this process, although it is unlikely the final boundaries of the land to be transferred will be determined until the final cleanup and closure plans are approved. However, the OLF will remain under the administrative jurisdiction of the Secretary of Energy.

10.4 Reporting Requirements

Annual reporting of data results, inspection results, repairs, and routine maintenance will be performed. These requirements may be combined into one report and/or with future Sitewide maintenance and monitoring reports.

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11.0 IMPLEMENTATION SCHEDULE

It is anticipated that the remedial action will take just over 6 months to complete and be implemented during Fiscal Year 2005. The approximate schedule for work follows.

- Mobilization – 20 days
- Pregrade Cut – 30 days
- Pregrade Fill – 70 days
- Fine Grading – 20 days
- Soil Cover – 40 days
- Vegetation and Erosion Control – 10 days
- Demobilization – 10 days

Most of these activities will be performed with some concurrent overlap. A detailed schedule for the construction will be developed during the design.

12.0 CLOSEOUT REPORT

Upon completion of the accelerated action at the OLF, a Closeout Report will be prepared in accordance with RFCA. The Closeout Report will document the work completed within the scope of this IM/IRA. The expected outline/content for the Closeout Report is as follows:

- Introduction;
- Remedial action description;
- Dates and duration of specific activities;
- Deviations from the decision document, if any;
- Final disposition of any wastes generated;
- Demarcation of wastes left in place (that is survey benchmarks and measurements);
- Demarcation of areas requiring access controls;
- A copy of the Vegetation Plan; and
- A copy of the Monitoring and Maintenance Plan.

Upon completion, the Closeout Report will be submitted for review and approval by CDPHE and EPA, and placed in the Administrative Record File.

13.0 ADMINISTRATIVE RECORD

The Administrative Record (AR) File for the proposed accelerated action to be conducted pursuant to this IM/IRA is available in the Rocky Flats Reading Room, located at:

Front Range Community College
3705 112th Avenue
Westminster, Colorado 80030

(303) 469-4435.

The AR File contains the references listed in Section 15.0, References.

Upon approval of the Final IM/IRA, the AR will consist of the approval letter, Final IM/IRA (which will include a Comment Responsiveness Summary), references listed in Section 15.0, References, and any additional documents identified in the Final IM/IRA for inclusion in the AR.

An AR File for the implementation phase of the Final IM/IRA will be maintained as governed by Site AR policies and procedures, pursuant to the RFCA Community Relation Plan. The Final Closeout Report for the project will be included in the AR File. In addition, project-specific information, such as project correspondence, work control documents, and other information generated as a direct result of this project, will be filed in the Project Record. The Project Record files will be transferred to Site Records Management upon completion of the Final Closeout Report.

14.0 COMMENT RESPONSIVENESS SUMMARY

Responses to comments on this IM/IRA received during the formal public comment period, including comments from the regulatory agencies, will be documented in the Appendix F.

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15.0 REFERENCES

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Appendix A

ARARs

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Appendix A – Applicable or Relevant and Appropriate Requirements

Requirement	Citation	Type	Comment
ATOMIC ENERGY ACT (AEA) [42 USC 2200 et. seq.]			
CHRONIC BERYLLIUM DISEASE PREVENTION PROGRAM	10 CFR 850	A	Establishes a program to reduce the number of workers currently exposed to beryllium in the course of their work at DOE facilities. The cited sections are followed in relation to determinations of beryllium contamination and release to the public.
• Definitions	.3		
• Release Criteria	.31		
• Waste Disposal	.32		
• Warning Labels	.38 (b-c)		
CLEAN AIR ACT (CAA), 42 USC 7401 *et seq.*			
COLORADO AIR QUALITY CONTROL COMMISSION (CAQCC) REGULATIONS	5 CCR 1001 (40 CFR 52, SUBPART G)		
• Emission Control Regulations for Particulates, Smokes, Carbon Monoxide, and Sulfur Oxides	5 CCR 1001-3 (CAQCC Reg. No. 1)		
➢ Smoke and Opacity	Section II.A.1	C	Air pollutant emissions from stationary sources (e.g., fuel-fired pumps, generators, and compressors, process vents/stacks) shall not exceed 20% opacity.
➢ Fugitive Particulate Emissions	Section III.D	A	Technologically feasible and economically reasonable control measures and operating procedures will be employed to reduce, prevent, and control particulate emissions.
▪ Construction Activities	III.D.2(b)		
▪ Storage and Handling of Material	III.D.2(c)		
▪ Haul Roads	III.D.2(e)		
▪ Haul Trucks	III.D.2(f)		
• Air Pollutant Emission Notices (APEN), Construction Permits and Fees, Operating Permits, and Including the Prevention of Significant Deterioration	5 CCR 1001-5 (CAQCC Reg. No. 3)		
➢ APEN Requirements	Part A, Section II	C	An APEN shall be filed with CDPHE prior to construction, modification, or alteration

A – Action-Specific ARAR; C- Chemical-Specific ARAR; L – Location-Specific ARAR; TBC – To Be Considered

Appendix A – Applicable or Relevant and Appropriate Requirements

Requirement	Citation	Type	Comment
CLEAN AIR ACT (CAA), 42 USC 7401 *et seq.*			of, or allowing emissions of air pollutants from, any activity. Certain activities are exempted from APEN requirements per specific exemptions listed in the regulation.
➢ Construction Permits, Including Regulations for the Prevention of Significant Deterioration (PDS)	Part B		Construction permits are not required for CERCLA activities; however, substantive requirements that would normally be associated with construction permits will apply.
▪ Construction Permits	Section III	C	Construction permits are not required for CERCLA activities; however, substantive requirements that would normally be associated with construction permits will apply. Also, fuel-fired equipment (e.g., generators, compressors) associated with these activities may require permitting.
▪ Non-Attainment Area Requirements	Section IV.D.2	A/C/L	Even though CERCLA activities are exempt from construction permit requirements, non-attainment area requirements may apply if emissions of certain pollutants exceed certain threshold limits. The requirements include emissions reductions or offsets, and strict emission control requirements. Although RFETS is no longer a non-attainment area, this requirement is retained in the event the non-attainment designation changes.
▪ Prevention of Significant Deterioration Requirements	Section IV.D.3	A/C/L	Even though CERCLA activities are exempt from construction permit requirements, PSD requirements may apply if emissions of certain pollutants exceed certain threshold limits. The requirements include strict emission control requirements, source impact modeling, and pre-construction and post-construction monitoring.
• Emissions of Volatile Organic Compounds (VOCs)	5 CCR 1001-9 (CAQCC Reg. No. 7)		
• General Requirements for Storage and Transfer of VOCs	Section III.B	A	Applies to the transfer of VOCs to a tank larger than 56 gallons. In such cases, submerged-fill or bottom-fill techniques must be used.
• Disposal of VOCs	Section V	A	Prohibits the disposal of VOCs by evaporation or spillage.
• Storage and Transfer of Petroleum Liquid	Section VI	A	Regulated storage and transfer of petroleum liquids.
• Control of Hazardous Air Pollutants	5 CCR 1001-10 (CAQCC Reg. No. 8), 40 CFR 61, Subpart A		This subpart details the general provisions that apply to sources subject to National Emission Standards for Hazardous Air Pollutants (NESHAPs).
• National Emission Standards for Emissions of Radionuclides Other Than Radon From Department of Energy Facilities	5 CCR 1001-10 (CAQCC Reg. No. 8) 40 CFR 61, Subpart H		

A – Action-Specific ARAR; C- Chemical-Specific ARAR; L – Location-Specific ARAR; TBC – To Be Considered

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Appendix A – Applicable or Relevant and Appropriate Requirements

Requirement	Citation	Type	Comment
CLEAN AIR ACT (CAA), 42 USC 7401 *et seq.*			
➢ Standard	61.92	C/L	This section establishes a radionuclide emission standard equal to those emissions that yield an effective does equivalent (EDE) of 10 mrem/year to any member of the public. The perimeter samplers in the Radioactive Ambient Air Monitoring Program (RAAMP) sampler network are used to verify compliance with the standard.
➢ Emission Monitoring and Test Procedures	61.93	C/A	This section establishes emission monitoring and testing protocols required to measure radionuclide emissions and calculated EDEs. This section also requires that radionuclide emissions measurements (i.e., stack monitoring) be made at all release points that have a potential to discharge radionuclides into the air which could cause an EDE to the most impacted member of the public in excess of 1% of the standard (i.e., 0.1 mrem/year).
➢ Compliance and Reporting	61.96	C/L	This section requires the Site to perform radionuclide air emission assessments of all new and modified sources. For sources that exceed the 0.1 mrem/year EDE threshold (controlled), the appropriate applications for approval must be submitted to EPA and CDPHE. Additional substantive requirements may apply if the activity requires agency approval.
FEDERAL WATER POLLUTION CONTROL ACT (aka Clean Water Act [CWA]), 33 USC 1251 *et seq.*			
NATIONAL POLLUTANT DISCHARGE ELIMINATION SYSTEM REGULATION • Storm Water Permit for Construction Activities • General Permits	 40 CFR 122.26 40 CFR 122.28	 A/L A/L	
DISCHARGES OF DREDGED OR FILL MATERIAL INTO WATERS OF THE UNITED STATES • Discharges Requiring Permits	33 USC 1344 33 CFR 323.3	A/L	
DOE COMPLIANCE WITH FLOODPLAIN/WETLANDS ENVIRONMENTAL REVIEW REQUIREMENTS COMPLIANCE WITH FLOODPLAIN/WETLANDS ENVIRONMENTAL REVIEW REQUIREMENTS	10 CFR 1022	A/L	

A – Action-Specific ARAR; C- Chemical-Specific ARAR; L – Location-Specific ARAR; TBC – To Be Considered

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Appendix A – Applicable or Relevant and Appropriate Requirements

Requirement	Citation	Type	Comment
FEDERAL WATER POLLUTION CONTROL ACT (aka Clean Water Act [CWA]), 33 USC 1251 *et seq.*			
• Floodplain/Wetlands Determination • Floodplain/Wetlands Assessment • Applicant Responsibilities	.11 .12 .13		
MIGRATORY BIRD TREATY ACT, 16 USC 701 *et seq.*			
TAKING, POSSESSION, TRANSPORTATION, SALE, PURCHASE, BARTER, EXPORTATION, AND IMPORTATION OF WILDLIFE AND PLANTS	50 CFR 10	A/L	Principally focuses on the taking and possession of birds protected under this regulation. Enforcement is predicated on location of the project and time of the year. Current list of protected birds is maintained by the Site Ecology group.
NATURAL RESOURCE AND WILDLIFE PROTECTION LAWS			
EARLY CONSULTATION	50 CFR 402.11	A/L	Identify and minimize early in the planning stage of action, any potential conflicts between the action and federally listed species.
BIOLOGICAL ASSESSMENT • Purpose • Preparation Requirements • Request for Information • Director's Response - No Listed Species or Critical Habitat Present - Listed Species or Critical Habitat Present • Verification of Current Accuracy or Species List • Contents • Identical/Similar to Previous Action • Permit Requirement • Completion Time • Submission of Biological Assessment	50 CFR 402.12	A/L	This is the process DOE needs to follow to evaluate the potential effects of the action on listed and proposed species and designated and proposed critical habitat and determine whether any such species or habitat are likely to be adversely affected by the action and is used in determining whether formal consultation or a conference is necessary.

A – Action-Specific ARAR; C- Chemical-Specific ARAR; L – Location-Specific ARAR; TBC – To Be Considered

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Appendix A – Applicable or Relevant and Appropriate Requirements

Requirement	Citation	Type	Comment
• Use of Biological Assessment			
INTERAGENCY COOPERATION • Informal Consultation	50 CFR 402	A/L	This is an optional process that includes all discussions, correspondence, etc., between the USFWS and the DOE. IT is designed to assist in determining whether formal consultation or a conference is required. If during it is determined by the DOE with concurrence of the USFWS that the action is not likely to adversely affect listed species or critical habitat, the consultation process is terminated and no further action is necessary. DOE shall review its actions at the earliest possible time to determine whether any action may affect listed species or critical habitat.
SOLID WASTE DISPOSAL ACT (aka: Resource Conservation and Recovery Act [RCRA]), 42 USC 6901 *et seq.*; SUBTITLE C: HAZARDOUS WASTE MANAGEMENT (Colorado Hazardous Waste Act [CHWA]), CRS 25-15-101 to -217			
Although the Colorado hazardous waste management regulations are similar to the federal requirements, both the federal and state regulatory citations are provided for reference purposes and to denote that both federal and state requirements were considered in establishing the identifying the ARAR requirement adopted for the remediation of the RFETS. Only substantive portions of the regulations are required under CERCLA actions for onsite activities.			
CLOSURE	6 CCR 1007-3, Part 265, Subpart N (40CFR 265, Subpart N)		
• Cover requirements (Landfills)			
Function with minimum maintenance; and	.310(a)(2)	A/C	Relevant and Appropriate
Accommodate settling and Subsidence so that the cover's integrity is maintained.	.310(a)(4)	A/C	Relevant and Appropriate
FEDERAL NOXIOUS WEED ACT (Pub. L. 93-629; 7 USC 2814 *et seq.*)			
MANAGEMENT OF UNDESIRABLE PLANTS ON FEDERAL LANDS	7 USC 2814		

A – Action-Specific ARAR; C- Chemical-Specific ARAR; L – Location-Specific ARAR; TBC – To Be Considered

Appendix A – Applicable or Relevant and Appropriate Requirements

Requirement	Citation	Type	Comment
FEDERAL NOXIOUS WEED ACT (Pub. L. 93-629; 7 USC 2814 *et seq.*)			
• Duties of Federal Agencies	(a)(3), (a)(4), (c)(1), (c)(2)	A	Federal agencies must complete and implement cooperative agreements with State agencies regarding the management of undesirable plant species on Federal lands under the agency's jurisdiction and establish integrated management systems to control or contain undesirable plant species targeted under cooperative agreements.
COLORADO NOXIOUS WEED ACT (CRS 35-5.5-101 *et seq.*)			
DUTY TO MANAGE NOXIOUS WEEDS	Section 104	A	It is the duty of all persons to use integrated methods to manage noxious weeds if the same are likely to be materially damaging to the land of neighboring landowners, and it is the duty of local governing bodies to assure that these plants are, in fact, managed.
COOPERATION WITH FEDERAL AND STATE AGENCIES	Section 111	A	The local governing bodies in Colorado are authorized to enter into cooperative agreements with federal and state agencies for the integrated management of noxious weeds within their respective territorial jurisdictions. The Jefferson County Noxious Weed Management Plan establishes the countywide strategy for the management, control, and eradication of noxious weeds in the County.
NATIONAL WILDLIFE REFUGE ACT			
NATIONAL WILDLIFE REFUGE SYSTEM ADMINISTRATION ACT	16 USC 668 et seq.	L	Relevant and Appropriate. Prohibits interference with natural growth or wildlife, on National Wildlife Refuges administered by the USFWS, unless permitted.

A – Action-Specific ARAR; C- Chemical-Specific ARAR; L – Location-Specific ARAR; TBC – To Be Considered

Appendix B

Environmental Data Tables

Table 1
Sampling and Analytical Summary for OLF Soil

Surface Soil			Subsurface Soil				
Location Code	Collection Date	Analyte Group	Location Code	Collection Date	Start Depth	End Depth	Analyte Group
INT. DITCH	8/8/1990	Metal	50592	12/15/1992	1.75	2	VOC
INT. DITCH	8/8/1990	PCB	50592	12/15/1992	3.75	4	VOC
INT. DITCH	8/8/1990	Pesticide	50592	12/15/1992	0	6	Metal
INT. DITCH	8/8/1990	SVOC	50592	12/15/1992	0	6	PCB
INT. DITCH	8/8/1990	VOC	50592	12/15/1992	0	6	Pesticide
SS505093	7/1/1993	Radionuclide	50592	12/15/1992	0	6	Radionuclide
SS505293	6/24/1993	Radionuclide	50592	12/15/1992	0	6	SVOC
SS505393	6/21/1993	Radionuclide	50592	12/15/1992	0	6	VOC
SS505493	6/30/1993	Radionuclide	50592	12/15/1992	4	6	VOC
SS505593	6/21/1993	Radionuclide	50592	12/15/1992	6	8	VOC
SS505693	6/21/1993	Radionuclide	50592	12/15/1992	8	10	VOC
SS505893	6/24/1993	Radionuclide	50592	12/15/1992	6	12	Metal
SS506293	1/8/1993	Metal	50592	12/15/1992	6	12	PCB
SS506293	1/8/1993	PCB	50592	12/15/1992	6	12	Pesticide
SS506293	1/8/1993	Pesticide	50592	12/15/1992	6	12	Radionuclide
SS506293	1/8/1993	Radionuclide	50592	12/15/1992	6	12	SVOC
SS506293	1/8/1993	SVOC	50592	12/15/1992	6	12	VOC
SS506293	1/8/1993	VOC	50592	12/15/1992	10	12	VOC
SS506493	1/8/1993	Metal	50592	12/15/1992	12	14	VOC
SS506493	1/8/1993	PCB	50592	12/15/1992	14	16	VOC
SS506493	1/8/1993	Pesticide	50592	12/15/1992	12	18	Metal
SS506493	1/8/1993	Radionuclide	50592	12/15/1992	12	18	PCB
SS506493	1/8/1993	SVOC	50592	12/15/1992	12	18	Pesticide
SS506493	1/8/1993	VOC	50592	12/15/1992	12	18	Radionuclide
SS506593	1/25/1993	Metal	50592	12/15/1992	12	18	SVOC
SS506593	1/25/1993	PCB	50592	12/15/1992	12	18	VOC
SS506593	1/25/1993	Pesticide	50592	12/15/1992	16	18	VOC
SS506593	1/25/1993	Radionuclide	50592	12/15/1992	18	20	VOC
SS506593	1/25/1993	SVOC	50592	12/15/1992	20	22	VOC
SS506593	1/25/1993	VOC	50592	12/15/1992	18	24	Metal
SS506693	1/25/1993	Metal	50592	12/15/1992	18	24	PCB
SS506693	1/25/1993	PCB	50592	12/15/1992	18	24	Pesticide
SS506693	1/25/1993	Pesticide	50592	12/15/1992	18	24	Radionuclide
SS506693	1/25/1993	Radionuclide	50592	12/15/1992	18	24	SVOC
SS506693	1/25/1993	SVOC	50592	12/15/1992	18	24	VOC
SS506693	1/25/1993	VOC	50592	12/15/1992	22	24	VOC
SS506793	1/15/1993	Metal	50592	12/15/1992	24	26	VOC
SS506793	1/15/1993	PCB	50592	12/15/1992	26	28	VOC
SS506793	1/15/1993	Pesticide	50592	12/16/1992	0	32	Metal
SS506793	1/15/1993	Radionuclide	50592	12/16/1992	0	32	PCB
SS506793	1/15/1993	SVOC	50592	12/16/1992	0	32	Pesticide
SS506793	1/15/1993	VOC	50592	12/16/1992	0	32	Radionuclide
SS506893	1/15/1993	Metal	50592	12/16/1992	0	32	SVOC
SS506893	1/15/1993	PCB	50592	12/16/1992	0	32	VOC
SS506893	1/15/1993	Pesticide	50692	12/8/1992	0	2	VOC
SS506893	1/15/1993	Radionuclide	50692	12/8/1992	0	4	VOC
SS506893	1/15/1993	SVOC	50692	12/8/1992	0	6	Metal
SS506893	1/15/1993	VOC	50692	12/8/1992	0	6	PCB
SS507093	1/25/1993	Metal	50692	12/8/1992	0	6	Pesticide
SS507093	1/25/1993	PCB	50692	12/8/1992	0	6	Radionuclide
SS507093	1/25/1993	Pesticide	50692	12/8/1992	0	6	SVOC
SS507093	1/25/1993	Radionuclide	50692	12/8/1992	0	6	VOC
SS507093	1/25/1993	SVOC	50692	12/8/1992	4	6	VOC
SS507093	1/25/1993	VOC	50692	12/8/1992	6	8	VOC

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SS507193	1/25/1993	Metal	50692	12/8/1992	8	10	VOC
SS507193	1/25/1993	PCB	50692	12/9/1992	6	12	Metal
SS507193	1/25/1993	Pesticide	50692	12/9/1992	6	12	PCB
SS507193	1/25/1993	Radionuclide	50692	12/9/1992	6	12	Pesticide
SS507193	1/25/1993	SVOC	50692	12/9/1992	6	12	Radionuclide
SS507193	1/25/1993	VOC	50692	12/9/1992	6	12	SVOC
SS507293	1/25/1993	Metal	50692	12/9/1992	6	12	VOC
SS507293	1/25/1993	PCB	50692	12/9/1992	10	12	VOC
SS507293	1/25/1993	Pesticide	50692	12/9/1992	12	14	VOC
SS507293	1/25/1993	Radionuclide	50692	12/9/1992	14	16	VOC
SS507293	1/25/1993	SVOC	50692	12/10/1992	0	14	Metal
SS507293	1/25/1993	VOC	50692	12/10/1992	0	14	PCB
SS507393	1/20/1993	Metal	50692	12/10/1992	0	14	Pesticide
SS507393	1/20/1993	PCB	50692	12/10/1992	0	14	Radionuclide
SS507393	1/20/1993	Pesticide	50692	12/10/1992	0	14	SVOC
SS507393	1/20/1993	Radionuclide	50692	12/10/1992	0	14	VOC
SS507393	1/20/1993	SVOC	50792	12/11/1992	0	2	VOC
SS507393	1/20/1993	VOC	50792	12/11/1992	0	4	VOC
SS507493	1/25/1993	Metal	50792	12/11/1992	0	6	Metal
SS507493	1/25/1993	PCB	50792	12/11/1992	0	6	PCB
SS507493	1/25/1993	Pesticide	50792	12/11/1992	0	6	Pesticide
SS507493	1/25/1993	Radionuclide	50792	12/11/1992	0	6	Radionuclide
SS507493	1/25/1993	SVOC	50792	12/11/1992	0	6	SVOC
SS507493	1/25/1993	VOC	50792	12/11/1992	0	6	VOC
SS507593	1/25/1993	Metal	50792	12/11/1992	4	6	VOC
SS507593	1/25/1993	PCB	50792	12/11/1992	6	8	VOC
SS507593	1/25/1993	Pesticide	50792	12/11/1992	0	10	Metal
SS507593	1/25/1993	Radionuclide	50792	12/11/1992	0	10	PCB
SS507593	1/25/1993	SVOC	50792	12/11/1992	0	10	Pesticide
SS507593	1/25/1993	VOC	50792	12/11/1992	0	10	Radionuclide
SS507693	1/20/1993	Metal	50792	12/11/1992	0	10	SVOC
SS507693	1/20/1993	PCB	50792	12/11/1992	0	10	VOC
SS507693	1/20/1993	Pesticide	50792	12/11/1992	8	10	VOC
SS507693	1/20/1993	Radionuclide	50892	12/14/1992	0	2	VOC
SS507693	1/20/1993	SVOC	50892	12/14/1992	2	4	VOC
SS507693	1/20/1993	VOC	50892	12/14/1992	0	6	Metal
SS507793	1/26/1993	Metal	50892	12/14/1992	0	6	PCB
SS507793	1/26/1993	PCB	50892	12/14/1992	0	6	Pesticide
SS507793	1/26/1993	Pesticide	50892	12/14/1992	0	6	Radionuclide
SS507793	1/26/1993	Radionuclide	50892	12/14/1992	0	6	SVOC
SS507793	1/26/1993	SVOC	50892	12/14/1992	0	6	VOC
SS507793	1/26/1993	VOC	50892	12/14/1992	4	6	VOC
SS507893	1/26/1993	Metal	50892	12/14/1992	6	8	VOC
SS507893	1/26/1993	PCB	50892	12/14/1992	8	10	VOC
SS507893	1/26/1993	Pesticide	50892	12/14/1992	6	12	Metal
SS507893	1/26/1993	Radionuclide	50892	12/14/1992	6	12	PCB
SS507893	1/26/1993	SVOC	50892	12/14/1992	6	12	Pesticide
SS507893	1/26/1993	VOC	50892	12/14/1992	6	12	Radionuclide
SS507993	1/26/1993	Metal	50892	12/14/1992	6	12	SVOC
SS507993	1/26/1993	PCB	50892	12/14/1992	6	12	VOC
SS507993	1/26/1993	Pesticide	50892	12/14/1992	10	12	VOC
SS507993	1/26/1993	Radionuclide	50892	12/14/1992	8	16	Metal
SS507993	1/26/1993	SVOC	50892	12/14/1992	8	16	PCB
SS507993	1/26/1993	VOC	50892	12/14/1992	8	16	Pesticide
SS508093	1/27/1993	Metal	50892	12/14/1992	8	16	Radionuclide
SS508093	1/27/1993	PCB	50892	12/14/1992	8	16	SVOC

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SS508093	1/27/1993	Pesticide	50892	12/14/1992	8	16	VOC
SS508093	1/27/1993	Radionuclide	50992	12/18/1992	0	2	VOC
SS508093	1/27/1993	SVOC	50992	12/18/1992	0	6	Metal
SS508093	1/27/1993	VOC	50992	12/18/1992	0	6	PCB
SS508193	1/20/1993	Metal	50992	12/18/1992	0	6	Pesticide
SS508193	1/20/1993	PCB	50992	12/18/1992	0	6	Radionuclide
SS508193	1/20/1993	Pesticide	50992	12/18/1992	0	6	SVOC
SS508193	1/20/1993	Radionuclide	50992	12/18/1992	0	6	VOC
SS508193	1/20/1993	SVOC	50992	12/18/1992	4	6	VOC
SS508193	1/20/1993	VOC	50992	12/18/1992	6	8	VOC
SS508293	1/26/1993	Metal	50992	12/18/1992	8	10	VOC
SS508293	1/26/1993	PCB	50992	12/18/1992	6	12	Metal
SS508293	1/26/1993	Pesticide	50992	12/18/1992	6	12	PCB
SS508293	1/26/1993	Radionuclide	50992	12/18/1992	6	12	Pesticide
SS508293	1/26/1993	SVOC	50992	12/18/1992	6	12	Radionuclide
SS508293	1/26/1993	VOC	50992	12/18/1992	6	12	SVOC
SS508393	1/26/1993	Metal	50992	12/18/1992	6	12	VOC
SS508393	1/26/1993	PCB	50992	12/18/1992	12	14	VOC
SS508393	1/26/1993	Pesticide	50992	12/18/1992	0	16	Metal
SS508393	1/26/1993	Radionuclide	50992	12/18/1992	0	16	PCB
SS508393	1/26/1993	SVOC	50992	12/18/1992	0	16	Pesticide
SS508393	1/26/1993	VOC	50992	12/18/1992	0	16	Radionuclide
SS508493	1/26/1993	Metal	50992	12/18/1992	0	16	SVOC
SS508493	1/26/1993	PCB	50992	12/18/1992	0	16	VOC
SS508493	1/26/1993	Pesticide	50992	12/18/1992	14	16	VOC
SS508493	1/26/1993	Radionuclide	51092	12/21/1992	0	2	VOC
SS508493	1/26/1993	SVOC	51092	12/21/1992	2	4	VOC
SS508493	1/26/1993	VOC	51092	12/21/1992	0	6	Metal
SS508593	1/27/1993	Metal	51092	12/21/1992	0	6	PCB
SS508593	1/27/1993	PCB	51092	12/21/1992	0	6	Pesticide
SS508593	1/27/1993	Pesticide	51092	12/21/1992	0	6	Radionuclide
SS508593	1/27/1993	Radionuclide	51092	12/21/1992	0	6	SVOC
SS508593	1/27/1993	SVOC	51092	12/21/1992	0	6	VOC
SS508593	1/27/1993	VOC	51092	12/21/1992	4	6	VOC
SS508693	1/21/1993	Metal	51092	12/21/1992	6	8	VOC
SS508693	1/21/1993	PCB	51092	12/21/1992	0	12	Metal
SS508693	1/21/1993	Pesticide	51092	12/21/1992	0	12	PCB
SS508693	1/21/1993	Radionuclide	51092	12/21/1992	0	12	Pesticide
SS508693	1/21/1993	SVOC	51092	12/21/1992	0	12	Radionuclide
SS508693	1/21/1993	VOC	51092	12/21/1992	0	12	SVOC
SS508793	2/1/1993	Metal	51092	12/21/1992	0	12	VOC
SS508793	2/1/1993	PCB	57594	10/31/1994	1.7	2	VOC
SS508793	2/1/1993	Pesticide	57594	10/31/1994	3.7	4	VOC
SS508793	2/1/1993	Radionuclide	57594	10/31/1994	0	6	Metal
SS508793	2/1/1993	SVOC	57594	10/31/1994	0	6	PCB
SS508793	2/1/1993	VOC	57594	10/31/1994	0	6	Pesticide
SS508893	1/26/1993	Metal	57594	10/31/1994	0	6	Radionuclide
SS508893	1/26/1993	PCB	57594	10/31/1994	0	6	SVOC
SS508893	1/26/1993	Pesticide	57594	10/31/1994	0	6	VOC
SS508893	1/26/1993	Radionuclide	57594	10/31/1994	5.7	6	VOC
SS508893	1/26/1993	SVOC	57594	10/31/1994	7.7	8	VOC
SS508893	1/26/1993	VOC	57594	10/31/1994	6	12	Metal
SS508993	1/27/1993	Metal	57594	10/31/1994	6	12	PCB
SS508993	1/27/1993	PCB	57594	10/31/1994	6	12	Pesticide
SS508993	1/27/1993	Pesticide	57594	10/31/1994	6	12	Radionuclide
SS508993	1/27/1993	Radionuclide	57594	10/31/1994	6	12	SVOC

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SS508993	1/27/1993	SVOC	57594	10/31/1994	6	12	VOC
SS508993	1/27/1993	VOC	57594	10/31/1994	15.7	16	VOC
SS509093	2/2/1993	Metal	57594	11/4/1994	18	23	Metal
SS509093	2/2/1993	PCB	57594	11/4/1994	18	23	PCB
SS509093	2/2/1993	Pesticide	57594	11/4/1994	18	23	Pesticide
SS509093	2/2/1993	Radionuclide	57594	11/4/1994	18	23	Radionuclide
SS509093	2/2/1993	SVOC	57594	11/4/1994	18	23	SVOC
SS509093	2/2/1993	VOC	57594	11/4/1994	18	23	VOC
SS509193	1/21/1993	Metal	57594	11/7/1994	18	23	Metal
SS509193	1/21/1993	PCB	57594	11/7/1994	18	23	PCB
SS509193	1/21/1993	Pesticide	57594	11/7/1994	18	23	Pesticide
SS509193	1/21/1993	Radionuclide	57594	11/7/1994	18	23	Radionuclide
SS509193	1/21/1993	SVOC	57594	11/7/1994	18	23	SVOC
SS509193	1/21/1993	VOC	57594	11/7/1994	18	23	VOC
SS509293	2/1/1993	Metal	57594	11/8/1994	84.9	90.4	Metal
SS509293	2/1/1993	PCB	57594	11/8/1994	84.9	90.4	PCB
SS509293	2/1/1993	Pesticide	57594	11/8/1994	84.9	90.4	Pesticide
SS509293	2/1/1993	Radionuclide	57594	11/8/1994	84.9	90.4	Radionuclide
SS509293	2/1/1993	SVOC	57594	11/8/1994	84.9	90.4	SVOC
SS509293	2/1/1993	VOC	57594	11/8/1994	84.9	90.4	VOC
SS509393	2/1/1993	Metal	57594	11/29/1994	24	105	Metal
SS509393	2/1/1993	PCB	57594	11/29/1994	24	105	PCB
SS509393	2/1/1993	Pesticide	57594	11/29/1994	24	105	Pesticide
SS509393	2/1/1993	Radionuclide	57594	11/29/1994	24	105	Radionuclide
SS509393	2/1/1993	SVOC	57594	11/29/1994	24	105	SVOC
SS509393	2/1/1993	VOC	57594	11/29/1994	24	105	VOC
SS509493	1/27/1993	Metal	58393	5/12/1993	3.25	3.5	VOC
SS509493	1/27/1993	PCB	58393	5/12/1993	0	6	Metal
SS509493	1/27/1993	Pesticide	58393	5/12/1993	0	6	PCB
SS509493	1/27/1993	Radionuclide	58393	5/12/1993	0	6	Pesticide
SS509493	1/27/1993	SVOC	58393	5/12/1993	0	6	Radionuclide
SS509493	1/27/1993	VOC	58393	5/12/1993	0	6	SVOC
SS509593	1/28/1993	Metal	58393	5/12/1993	0	6	VOC
SS509593	1/28/1993	PCB	58393	5/12/1993	6.45	6.7	VOC
SS509593	1/28/1993	Pesticide	58393	5/12/1993	10.4	10.7	VOC
SS509593	1/28/1993	Radionuclide	58393	5/12/1993	6	12.7	Metal
SS509593	1/28/1993	SVOC	58393	5/12/1993	6	12.7	PCB
SS509593	1/28/1993	VOC	58393	5/12/1993	6	12.7	Pesticide
SS509693	6/21/1993	Metal	58393	5/12/1993	6	12.7	Radionuclide
SS509693	6/21/1993	PCB	58393	5/12/1993	6	12.7	SVOC
SS509693	6/21/1993	Pesticide	58393	5/12/1993	6	12.7	VOC
SS509693	6/21/1993	Radionuclide	58393	5/12/1993	19.5	21.5	Metal
SS509693	6/21/1993	SVOC	58393	5/12/1993	19.5	21.5	Radionuclide
SS509693	6/21/1993	VOC	58393	5/12/1993	19.5	21.5	VOC
SS509793	1/21/1993	Metal	58493	5/13/1993	3.15	3.4	VOC
SS509793	1/21/1993	PCB	58493	5/13/1993	2	4	VOC
SS509793	1/21/1993	Pesticide	58493	5/13/1993	0	6	Metal
SS509793	1/21/1993	Radionuclide	58493	5/13/1993	0	6	PCB
SS509793	1/21/1993	SVOC	58493	5/13/1993	0	6	Pesticide
SS509793	1/21/1993	VOC	58493	5/13/1993	0	6	Radionuclide
SS509893	2/1/1993	Metal	58493	5/13/1993	0	6	SVOC
SS509893	2/1/1993	PCB	58493	5/13/1993	0	6	VOC
SS509893	2/1/1993	Pesticide	58493	5/13/1993	6	8	VOC
SS509893	2/1/1993	Radionuclide	58493	5/13/1993	8	10	VOC
SS509893	2/1/1993	SVOC	58493	5/13/1993	6	12	Metal
SS509893	2/1/1993	VOC	58493	5/13/1993	6	12	PCB

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SS509993	2/1/1993	Metal	58493	5/13/1993	6	12	Pesticide
SS509993	2/1/1993	PCB	58493	5/13/1993	6	12	Radionuclide
SS509993	2/1/1993	Pesticide	58493	5/13/1993	6	12	SVOC
SS509993	2/1/1993	Radionuclide	58493	5/13/1993	6	12	VOC
SS509993	2/1/1993	SVOC	58494	10/13/1994	2	2.5	VOC
SS509993	2/1/1993	VOC	58494	10/13/1994	4	4.5	VOC
SS510093	1/27/1993	Metal	58494	10/13/1994	0	6	Metal
SS510093	1/27/1993	PCB	58494	10/13/1994	0	6	PCB
SS510093	1/27/1993	Pesticide	58494	10/13/1994	0	6	Pesticide
SS510093	1/27/1993	Radionuclide	58494	10/13/1994	0	6	Radionuclide
SS510093	1/27/1993	SVOC	58494	10/13/1994	0	6	SVOC
SS510093	1/27/1993	VOC	58494	10/13/1994	0	6	VOC
SS510193	1/28/1993	Metal	58494	10/13/1994	6	6.5	VOC
SS510193	1/28/1993	PCB	58494	10/13/1994	8	8.5	VOC
SS510193	1/28/1993	Pesticide	58494	10/13/1994	6	9.5	Metal
SS510193	1/28/1993	Radionuclide	58494	10/13/1994	6	9.5	PCB
SS510293	6/21/1993	Metal	58494	10/13/1994	6	9.5	Pesticide
SS510293	6/21/1993	PCB	58494	10/13/1994	6	9.5	Radionuclide
SS510293	6/21/1993	Pesticide	58494	10/13/1994	6	9.5	SVOC
SS510293	6/21/1993	Radionuclide	58494	10/13/1994	6	9.5	VOC
SS510293	6/21/1993	SVOC	58494	10/13/1994	9.5	10	VOC
SS510293	6/21/1993	VOC	58593	5/14/1993	0	2	Metal
SS510393	1/21/1993	Metal	58593	5/14/1993	0	2	Radionuclide
SS510393	1/21/1993	PCB	58593	5/14/1993	0	2	VOC
SS510393	1/21/1993	Pesticide	58593	5/14/1993	2	4	VOC
SS510393	1/21/1993	Radionuclide	58593	5/14/1993	0	6	Metal
SS510393	1/21/1993	SVOC	58593	5/14/1993	0	6	PCB
SS510393	1/21/1993	VOC	58593	5/14/1993	0	6	Pesticide
SS510493	2/1/1993	Metal	58593	5/14/1993	0	6	Radionuclide
SS510493	2/1/1993	PCB	58593	5/14/1993	0	6	SVOC
SS510493	2/1/1993	Pesticide	58593	5/14/1993	0	6	VOC
SS510493	2/1/1993	Radionuclide	58593	5/14/1993	4	6	VOC
SS510493	2/1/1993	SVOC	58593	5/14/1993	6	8	VOC
SS510493	2/1/1993	VOC	58593	5/14/1993	8	10	VOC
SS510593	1/28/1993	Metal	58593	5/14/1993	6	12.5	Metal
SS510593	1/28/1993	PCB	58593	5/14/1993	6	12.5	PCB
SS510593	1/28/1993	Pesticide	58593	5/14/1993	6	12.5	Pesticide
SS510593	1/28/1993	Radionuclide	58593	5/14/1993	6	12.5	Radionuclide
SS510593	1/28/1993	SVOC	58593	5/14/1993	6	12.5	SVOC
SS510593	1/28/1993	VOC	58593	5/14/1993	6	12.5	VOC
SS510693	1/28/1993	Metal	58593	5/14/1993	10.5	12.5	VOC
SS510693	1/28/1993	PCB	58593	5/14/1993	12.5	14.1	VOC
SS510693	1/28/1993	Pesticide	58593	5/14/1993	14.1	16.1	VOC
SS510693	1/28/1993	Radionuclide	58593	5/14/1993	12.5	18.1	Metal
SS510693	1/28/1993	SVOC	58593	5/14/1993	12.5	18.1	PCB
SS510693	1/28/1993	VOC	58593	5/14/1993	12.5	18.1	Pesticide
SS510793	1/28/1993	Metal	58593	5/14/1993	12.5	18.1	Radionuclide
SS510793	1/28/1993	PCB	58593	5/14/1993	12.5	18.1	SVOC
SS510793	1/28/1993	Pesticide	58593	5/14/1993	12.5	18.1	VOC
SS510793	1/28/1993	Radionuclide	58593	5/14/1993	16.1	18.1	VOC
SS510893	1/28/1993	Metal	58693	5/17/1993	0	2	Metal
SS510893	1/28/1993	PCB	58693	5/17/1993	0	2	Radionuclide
SS510893	1/28/1993	Pesticide	58693	5/17/1993	2	4	VOC
SS510893	1/28/1993	Radionuclide	58693	5/17/1993	0	6	Metal
SS510893	1/28/1993	SVOC	58693	5/17/1993	0	6	PCB
SS510893	1/28/1993	VOC	58693	5/17/1993	0	6	Pesticide

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SS510993	2/2/1993	Metal	58693	5/17/1993	0	6	Radionuclide
SS510993	2/2/1993	PCB	58693	5/17/1993	0	6	SVOC
SS510993	2/2/1993	Pesticide	58693	5/17/1993	0	6	VOC
SS510993	2/2/1993	Radionuclide	58693	5/17/1993	6.2	8.2	VOC
SS510993	2/2/1993	SVOC	58693	5/17/1993	6	12	Metal
SS510993	2/2/1993	VOC	58693	5/17/1993	6	12	PCB
SS511093	2/2/1993	Metal	58693	5/17/1993	6	12	Pesticide
SS511093	2/2/1993	PCB	58693	5/17/1993	6	12	Radionuclide
SS511093	2/2/1993	Pesticide	58693	5/17/1993	6	12	SVOC
SS511093	2/2/1993	Radionuclide	58693	5/17/1993	6	12	VOC
SS511093	2/2/1993	SVOC	58693	5/17/1993	10.3	12	VOC
SS511093	2/2/1993	VOC	58693	5/18/1993	15.5	17.5	VOC
SS511193	2/2/1993	Metal	58693	5/18/1993	12	19.5	Metal
SS511193	2/2/1993	PCB	58693	5/18/1993	12	19.5	PCB
SS511193	2/2/1993	Pesticide	58693	5/18/1993	12	19.5	Pesticide
SS511193	2/2/1993	Radionuclide	58693	5/18/1993	12	19.5	Radionuclide
SS511193	2/2/1993	SVOC	58693	5/18/1993	12	19.5	SVOC
SS511193	2/2/1993	VOC	58693	5/18/1993	12	19.5	VOC
SS511293	2/2/1993	Metal	58693	5/18/1993	19.8	20.1	VOC
SS511293	2/2/1993	PCB	58693	5/18/1993	21.5	23.5	VOC
SS511293	2/2/1993	Pesticide	58693	5/18/1993	19.5	25.5	Metal
SS511293	2/2/1993	Radionuclide	58693	5/18/1993	19.5	25.5	PCB
SS511293	2/2/1993	SVOC	58693	5/18/1993	19.5	25.5	Pesticide
SS511293	2/2/1993	VOC	58693	5/18/1993	19.5	25.5	Radionuclide
SS511493	2/2/1993	Metal	58693	5/18/1993	19.5	25.5	SVOC
SS511493	2/2/1993	PCB	58693	5/18/1993	19.5	25.5	VOC
SS511493	2/2/1993	Pesticide	58693	5/18/1993	23.5	25.5	VOC
SS511493	2/2/1993	Radionuclide	58693	5/18/1993	25.5	27.5	VOC
SS511493	2/2/1993	SVOC	58693	5/18/1993	25.5	29.5	Metal
SS511493	2/2/1993	VOC	58693	5/18/1993	25.5	29.5	PCB
SS515593	7/1/1993	Radionuclide	58693	5/18/1993	25.5	29.5	Pesticide
SS515693	7/1/1993	Radionuclide	58693	5/18/1993	25.5	29.5	Radionuclide
			58693	5/18/1993	25.5	29.5	SVOC
			58693	5/18/1993	25.5	29.5	VOC
			58693	5/18/1993	27.5	29.5	VOC
			59293	6/4/1993	0	2	Metal
			59293	6/4/1993	0	2	Radionuclide
			59293	6/4/1993	0	2	VOC
			59293	6/4/1993	2	4	VOC
			59293	6/4/1993	0	6	Metal
			59293	6/4/1993	0	6	PCB
			59293	6/4/1993	0	6	Pesticide
			59293	6/4/1993	0	6	Radionuclide
			59293	6/4/1993	0	6	SVOC
			59293	6/4/1993	0	6	VOC
			59293	6/4/1993	4	6	VOC
			59293	6/4/1993	6	8	VOC
			59293	6/4/1993	8	10	VOC
			59293	6/4/1993	6	12	Metal
			59293	6/4/1993	6	12	PCB
			59293	6/4/1993	6	12	Pesticide
			59293	6/4/1993	6	12	Radionuclide
			59293	6/4/1993	6	12	SVOC
			59293	6/4/1993	6	12	VOC
			59293	6/4/1993	10	12	VOC
			59293	6/4/1993	12	14	VOC

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59293	6/4/1993	12	18.9	Metal
59293	6/4/1993	12	18.9	PCB
59293	6/4/1993	12	18.9	Pesticide
59293	6/4/1993	12	18.9	Radionuclide
59293	6/4/1993	12	18.9	SVOC
59293	6/4/1993	12	18.9	VOC
59493	6/14/1993	0.4	2	Metal
59493	6/14/1993	0.4	2	Radionuclide
59493	6/14/1993	0.4	2	VOC
59493	6/14/1993	0	6.3	Metal
59493	6/14/1993	0	6.3	PCB
59493	6/14/1993	0	6.3	Pesticide
59493	6/14/1993	0	6.3	Radionuclide
59493	6/14/1993	0	6.3	SVOC
59493	6/14/1993	0	6.3	VOC
59493	6/14/1993	4.9	6.9	VOC
59493	6/14/1993	6.9	12.9	Metal
59493	6/14/1993	6.9	12.9	PCB
59493	6/14/1993	6.9	12.9	Pesticide
59493	6/14/1993	6.9	12.9	Radionuclide
59493	6/14/1993	6.9	12.9	SVOC
59493	6/14/1993	6.9	12.9	VOC
59493	6/14/1993	10.9	12.9	VOC
59493	6/14/1993	14.9	16.6	VOC
59493	6/14/1993	12.9	17.8	Metal
59493	6/14/1993	12.9	17.8	PCB
59493	6/14/1993	12.9	17.8	Pesticide
59493	6/14/1993	12.9	17.8	Radionuclide
59493	6/14/1993	12.9	17.8	SVOC
59493	6/14/1993	12.9	17.8	VOC
59593	6/15/1993	0	2	Metal
59593	6/15/1993	0	2	Radionuclide
59593	6/15/1993	0	2	VOC
59593	6/15/1993	0	6	Metal
59593	6/15/1993	0	6	PCB
59593	6/15/1993	0	6	Pesticide
59593	6/15/1993	0	6	Radionuclide
59593	6/15/1993	0	6	SVOC
59593	6/15/1993	0	6	VOC
59593	6/15/1993	4	6	VOC
59593	6/15/1993	6	8	VOC
59593	6/15/1993	8	10	VOC
59593	6/15/1993	6	12	Metal
59593	6/15/1993	6	12	PCB
59593	6/15/1993	6	12	Pesticide
59593	6/15/1993	6	12	Radionuclide
59593	6/15/1993	6	12	SVOC
59593	6/15/1993	6	12	VOC
59593	6/15/1993	10	12	VOC
59593	6/15/1993	14.4	16.4	Metal
59593	6/15/1993	14.4	16.4	PCB
59593	6/15/1993	14.4	16.4	Pesticide
59593	6/15/1993	14.4	16.4	Radionuclide
59593	6/15/1993	14.4	16.4	SVOC
59593	6/15/1993	14.4	16.4	VOC
59793	6/11/1993	0	2	Metal

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59793	6/11/1993	0	2	Radionuclide
59793	6/11/1993	0	2	VOC
59793	6/11/1993	2	4	VOC
59793	6/11/1993	0	5.3	Metal
59793	6/11/1993	0	5.3	PCB
59793	6/11/1993	0	5.3	Pesticide
59793	6/11/1993	0	5.3	Radionuclide
59793	6/11/1993	0	5.3	SVOC
59793	6/11/1993	0	5.3	VOC
59793	6/11/1993	5.3	7.3	VOC
59793	6/11/1993	7.3	9.3	VOC
59793	6/11/1993	5.3	11.3	Metal
59793	6/11/1993	5.3	11.3	PCB
59793	6/11/1993	5.3	11.3	Pesticide
59793	6/11/1993	5.3	11.3	Radionuclide
59793	6/11/1993	5.3	11.3	SVOC
59793	6/11/1993	5.3	11.3	VOC
59793	6/11/1993	9.3	11.3	VOC
59793	6/11/1993	13.3	15.3	Metal
59793	6/11/1993	13.3	15.3	PCB
59793	6/11/1993	13.3	15.3	Pesticide
59793	6/11/1993	13.3	15.3	Radionuclide
59793	6/11/1993	13.3	15.3	SVOC
59793	6/11/1993	13.3	15.3	VOC
60993	6/23/1993	0	2	VOC
60993	6/23/1993	2	4	VOC
60993	6/23/1993	0	6	Metal
60993	6/23/1993	0	6	PCB
60993	6/23/1993	0	6	Pesticide
60993	6/23/1993	0	6	Radionuclide
60993	6/23/1993	0	6	SVOC
60993	6/23/1993	0	6	VOC
60993	6/23/1993	4	6	VOC
60993	6/23/1993	6	8	VOC
61093	6/23/1993	2	4	VOC
61093	6/23/1993	4	6	VOC
61093	6/23/1993	6	8	VOC
61093	6/23/1993	8	10	VOC
61093	6/23/1993	6	13	Metal
61093	6/23/1993	6	13	PCB
61093	6/23/1993	6	13	Pesticide
61093	6/23/1993	6	13	Radionuclide
61093	6/23/1993	6	13	SVOC
61093	6/23/1993	6	13	VOC
61093	6/23/1993	12	13	VOC
63193	6/22/1993	0	2	VOC
63193	6/22/1993	2	4	VOC
63193	6/22/1993	0	6	Metal
63193	6/22/1993	0	6	Radionuclide
63193	6/22/1993	4	6	VOC
63193	6/22/1993	6	8	VOC
63193	6/22/1993	8	10	VOC
63193	6/22/1993	6	12	Metal
63193	6/22/1993	6	12	PCB
63193	6/22/1993	6	12	Pesticide
63193	6/22/1993	6	12	Radionuclide

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	63193	6/22/1993	6	12	SVOC
	63193	6/22/1993	6	12	VOC
	63193	6/22/1993	10	12	VOC
	63193	6/22/1993	12	14	VOC
	63193	6/22/1993	14	16	VOC
	63193	6/22/1993	16	18	VOC
	63193	6/22/1993	12	20	Metal
	63193	6/22/1993	12	20	PCB
	63193	6/22/1993	12	20	Pesticide
	63193	6/22/1993	12	20	Radionuclide
	63193	6/22/1993	12	20	SVOC
	63193	6/22/1993	12	20	VOC
	63193	6/22/1993	18	20	VOC

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Analysis for Total Concentrations			Analysis for Dissolved Concentrations		
Location Code	Collection Date	Analyte Group	Location Code	Collection Date	Analyte Group
581	2/6/1992	Metal	581	2/6/1992	Metal
581	2/6/1992	Radionuclide	581	2/6/1992	Radionuclide
581	2/6/1992	VOC	10994	6/21/1994	Metal
581	2/6/1992	WQP	10994	9/2/1994	Metal
10994	6/21/1994	Metal	10994	11/30/1994	Metal
10994	6/21/1994	PCB	10994	2/8/1995	Metal
10994	6/21/1994	Pesticide	10994	2/8/1995	Radionuclide
10994	6/21/1994	SVOC	10994	5/24/1995	Metal
10994	6/21/1994	VOC	10994	5/24/1995	Radionuclide
10994	6/21/1994	WQP	10994	11/1/1995	Metal
10994	9/2/1994	PCB	10994	11/1/1995	Radionuclide
10994	9/2/1994	Pesticide	10994	3/14/1996	Metal
10994	9/2/1994	SVOC	10994	3/14/1996	Radionuclide
10994	9/2/1994	VOC	10994	6/7/1996	Metal
10994	11/30/1994	Metal	10994	6/7/1996	Radionuclide
10994	11/30/1994	PCB	10994	9/5/1996	Metal
10994	11/30/1994	Pesticide	10994	11/20/1996	Metal
10994	11/30/1994	SVOC	10994	11/20/1996	Radionuclide
10994	11/30/1994	VOC	10994	6/25/1997	Metal
10994	2/8/1995	Metal	10994	12/16/1997	Metal
10994	2/8/1995	Radionuclide	10994	7/14/1998	Radionuclide
10994	2/8/1995	VOC	10994	1/28/1999	Radionuclide
10994	2/8/1995	WQP	10994	7/19/1999	Metal
10994	5/24/1995	Metal	10994	7/19/1999	Radionuclide
10994	5/24/1995	PCB	10994	1/24/2000	Metal
10994	5/24/1995	Pesticide	10994	1/24/2000	Radionuclide
10994	5/24/1995	Radionuclide	10994	8/14/2000	Metal
10994	5/24/1995	SVOC	10994	8/14/2000	Radionuclide
10994	5/24/1995	VOC	10994	1/11/2001	Metal
10994	5/24/1995	WQP	10994	1/11/2001	Radionuclide
10994	11/1/1995	Radionuclide	10994	8/14/2001	Metal
10994	11/1/1995	WQP	10994	8/14/2001	Radionuclide
10994	3/14/1996	Radionuclide	10994	2/8/2002	Metal
10994	3/14/1996	VOC	10994	2/8/2002	Radionuclide
10994	3/14/1996	WQP	10994	7/15/2002	Metal
10994	6/7/1996	Radionuclide	10994	7/18/2002	Radionuclide
10994	6/7/1996	VOC	10994	1/14/2003	Metal
10994	6/7/1996	WQP	10994	1/14/2003	Radionuclide
10994	9/5/1996	Radionuclide	10994	2/25/2003	Metal
10994	11/20/1996	Radionuclide	10994	9/23/2003	Metal
10994	11/20/1996	VOC	10994	9/23/2003	Radionuclide
10994	11/20/1996	WQP	11094	12/20/1994	Metal
10994	6/25/1997	Radionuclide	11094	12/20/1994	Radionuclide
10994	6/25/1997	VOC	11094	2/10/1995	Metal
10994	6/25/1997	WQP	11094	2/10/1995	Radionuclide
10994	12/16/1997	Radionuclide	11094	5/22/1995	Metal
10994	12/16/1997	VOC	11094	5/22/1995	Radionuclide
10994	12/16/1997	WQP	20697	7/29/2004	Metal
10994	7/14/1998	Metal	20697	8/11/2004	Radionuclide
10994	7/14/1998	VOC	20797	8/11/2004	Metal

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10994	7/14/1998	WQP	20797	8/31/2004	Radionuclide
10994	9/24/1998	VOC	43392	9/22/1993	Radionuclide
10994	1/28/1999	Metal	43392	11/30/1993	Metal
10994	1/28/1999	VOC	43392	11/30/1993	Radionuclide
10994	1/28/1999	WQP	43392	3/4/1994	Radionuclide
10994	7/19/1999	VOC	43392	5/18/1994	Metal
10994	7/19/1999	WQP	43392	5/18/1994	Radionuclide
10994	1/24/2000	VOC	43392	8/18/1994	Metal
10994	1/24/2000	WQP	43392	8/18/1994	Radionuclide
10994	8/14/2000	VOC	43392	3/1/1995	Metal
10994	8/14/2000	WQP	43392	3/1/1995	Radionuclide
10994	1/11/2001	VOC	43392	5/18/1995	Metal
10994	1/11/2001	WQP	43392	5/18/1995	Radionuclide
10994	8/14/2001	VOC	43392	10/18/1995	Radionuclide
10994	1/31/2002	VOC	43392	1/17/1996	Radionuclide
10994	2/8/2002	WQP	43392	5/22/1996	Radionuclide
10994	7/15/2002	VOC	43392	8/29/1996	Metal
10994	7/23/2002	WQP	43392	11/12/1996	Metal
10994	1/14/2003	VOC	43392	11/12/1996	Radionuclide
10994	1/14/2003	WQP	43392	6/3/1997	Metal
10994	9/23/2003	VOC	43392	11/20/1997	Metal
10994	9/23/2003	WQP	43392	7/22/1998	Metal
11094	12/20/1994	Metal	43392	2/2/1999	Metal
11094	12/20/1994	PCB	43392	2/2/1999	Radionuclide
11094	12/20/1994	Pesticide	43392	7/20/1999	Metal
11094	12/20/1994	Radionuclide	43392	7/20/1999	Radionuclide
11094	12/20/1994	SVOC	43392	1/25/2000	Metal
11094	12/20/1994	VOC	43392	1/25/2000	Radionuclide
11094	12/20/1994	WQP	43392	9/7/2000	Metal
11094	2/10/1995	Metal	43392	9/7/2000	Radionuclide
11094	2/10/1995	PCB	43392	3/13/2001	Metal
11094	2/10/1995	Pesticide	43392	3/13/2001	Radionuclide
11094	2/10/1995	Radionuclide	43392	7/18/2001	Metal
11094	2/10/1995	SVOC	43392	7/18/2001	Radionuclide
11094	2/10/1995	VOC	43392	2/28/2002	Metal
11094	2/10/1995	WQP	43392	3/6/2002	Radionuclide
11094	5/22/1995	Metal	43392	8/21/2002	Radionuclide
11094	5/22/1995	Radionuclide	43392	9/6/2002	Metal
11094	5/22/1995	VOC	43392	9/11/2003	Metal
11094	5/22/1995	WQP	43392	9/11/2003	Radionuclide
11094	5/27/2003	VOC	56594	12/22/1994	Metal
20197	5/22/2001	VOC	56594	12/22/1994	Radionuclide
20397	5/17/2001	VOC	56594	4/25/1995	Metal
20597	5/22/2001	VOC	56594	4/25/1995	Radionuclide
20697	9/26/1997	VOC	56594	4/28/2003	Metal
20697	5/18/2001	VOC	56994	2/3/1995	Metal
20697	7/15/2004	VOC	56994	2/3/1995	Radionuclide
20797	7/30/1997	VOC	56994	5/16/1995	Metal
20797	5/17/2001	VOC	56994	5/16/1995	Radionuclide
20797	7/15/2004	VOC	56994	8/9/2004	Metal
21097	5/18/2001	VOC	56994	8/9/2004	Radionuclide
21097	7/15/2004	VOC	57094	8/11/2004	Metal

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43392	12/14/1992	Radionuclide	57094	8/11/2004	Radionuclide
43392	12/14/1992	VOC	57594	4/12/1995	Metal
43392	12/14/1992	WQP	57594	4/12/1995	Radionuclide
43392	9/22/1993	Radionuclide	5786	4/8/1987	Metal
43392	9/22/1993	VOC	5786	2/22/1990	Metal
43392	9/22/1993	WQP	5786	2/22/1990	Radionuclide
43392	11/30/1993	Radionuclide	5786	5/11/1990	Metal
43392	11/30/1993	VOC	5786	7/26/1990	Metal
43392	11/30/1993	WQP	5786	7/26/1990	Radionuclide
43392	3/4/1994	VOC	5786	10/12/1990	Radionuclide
43392	3/4/1994	WQP	5786	3/29/1991	Metal
43392	5/18/1994	Radionuclide	5786	3/29/1991	Radionuclide
43392	5/18/1994	VOC	5786	5/22/1991	Metal
43392	5/18/1994	WQP	5786	5/22/1991	Radionuclide
43392	8/18/1994	Radionuclide	5786	9/16/1991	Radionuclide
43392	8/18/1994	VOC	5786	2/18/1992	Metal
43392	8/18/1994	WQP	5786	2/18/1992	Radionuclide
43392	12/6/1994	Radionuclide	5786	4/29/1992	Metal
43392	12/6/1994	VOC	5786	4/29/1992	Radionuclide
43392	12/6/1994	WQP	5786	3/17/1993	Metal
43392	3/1/1995	Radionuclide	5786	3/17/1993	Radionuclide
43392	3/1/1995	VOC	5786	6/22/1993	Metal
43392	3/1/1995	WQP	5786	6/22/1993	Radionuclide
43392	5/18/1995	Radionuclide	5786	5/19/1994	Metal
43392	5/18/1995	VOC	5786	5/19/1994	Radionuclide
43392	5/18/1995	WQP	5786	2/28/1995	Metal
43392	10/18/1995	Radionuclide	5786	2/28/1995	Radionuclide
43392	10/18/1995	VOC	5786	5/22/1995	Metal
43392	1/17/1996	Radionuclide	5786	5/22/1995	Radionuclide
43392	1/17/1996	VOC	57894	1/22/1995	Metal
43392	5/22/1996	Radionuclide	57894	1/22/1995	Radionuclide
43392	5/22/1996	WQP	57894	4/25/1995	Metal
43392	8/29/1996	Radionuclide	57894	4/25/1995	Radionuclide
43392	8/29/1996	VOC	57994	5/11/1995	Metal
43392	8/29/1996	WQP	58094	12/21/1994	Metal
43392	11/12/1996	Radionuclide	58094	12/21/1994	Radionuclide
43392	11/12/1996	VOC	58094	4/26/1995	Metal
43392	11/12/1996	WQP	58094	4/26/1995	Radionuclide
43392	6/3/1997	VOC	58194	5/2/1995	Metal
43392	11/20/1997	VOC	58194	5/2/1995	Radionuclide
43392	7/22/1998	VOC	58494	5/3/1995	Metal
43392	2/2/1999	Radionuclide	58494	5/3/1995	Radionuclide
43392	2/2/1999	VOC	58494	8/12/2004	Metal
43392	7/20/1999	Radionuclide	58594	12/21/1994	Metal
43392	7/20/1999	VOC	58594	12/21/1994	Radionuclide
43392	1/25/2000	Radionuclide	58594	4/25/1995	Metal
43392	1/25/2000	VOC	58594	4/25/1995	Radionuclide
43392	9/7/2000	Radionuclide	59194	6/27/1995	Metal
43392	9/7/2000	VOC	59194	6/27/1995	Radionuclide
43392	3/1/2001	VOC	59194	8/9/2004	Metal
43392	3/27/2001	Radionuclide	59194	8/9/2004	Radionuclide
43392	7/18/2001	Radionuclide	59294	8/3/2004	Metal

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43392	7/18/2001	VOC	59294	8/3/2004	Radionuclide
43392	2/28/2002	VOC	59393	3/29/1994	Metal
43392	3/28/2002	Radionuclide	59393	3/29/1994	Radionuclide
43392	7/9/2002	VOC	59393	5/20/1994	Metal
43392	8/21/2002	Radionuclide	59393	5/20/1994	Radionuclide
43392	3/27/2003	VOC	59393	1/7/1995	Radionuclide
43392	8/27/2003	VOC	59393	3/8/1995	Metal
43392	9/29/2003	Radionuclide	59393	3/8/1995	Radionuclide
56594	12/22/1994	PCB	59393	4/26/1995	Metal
56594	12/22/1994	Pesticide	59393	4/26/1995	Radionuclide
56594	12/22/1994	Radionuclide	59393	11/16/1995	Metal
56594	12/22/1994	SVOC	59393	11/16/1995	Radionuclide
56594	12/22/1994	VOC	59393	4/30/1996	Metal
56594	12/22/1994	WQP	59393	4/30/1996	Radionuclide
56594	4/25/1995	Metal	59393	11/8/1996	Radionuclide
56594	4/25/1995	Radionuclide	59493	6/25/1993	Metal
56594	4/25/1995	SVOC	59493	6/25/1993	Radionuclide
56594	4/25/1995	VOC	59493	8/11/1993	Metal
56594	4/25/1995	WQP	59493	8/11/1993	Radionuclide
56594	4/28/2003	Radionuclide	59493	11/9/1993	Metal
56594	4/28/2003	VOC	59493	11/9/1993	Radionuclide
56994	2/3/1995	PCB	59493	3/14/1994	Metal
56994	2/3/1995	Pesticide	59493	3/14/1994	Radionuclide
56994	2/3/1995	Radionuclide	59493	5/9/1994	Metal
56994	2/3/1995	SVOC	59493	5/9/1994	Radionuclide
56994	2/3/1995	VOC	59493	8/19/1994	Metal
56994	2/3/1995	WQP	59493	8/19/1994	Radionuclide
56994	5/16/1995	Radionuclide	59493	10/21/1994	Metal
56994	5/16/1995	SVOC	59493	10/21/1994	Radionuclide
56994	5/16/1995	VOC	59493	1/4/1995	Metal
56994	5/16/1995	WQP	59493	1/4/1995	Radionuclide
56994	6/6/2001	VOC	59493	3/9/1995	Metal
56994	8/9/2004	VOC	59493	3/9/1995	Radionuclide
57094	6/1/1995	SVOC	59493	6/9/1995	Metal
57094	6/1/1995	VOC	59493	6/9/1995	Radionuclide
57094	6/11/2001	VOC	59593	6/25/1993	Metal
57094	5/8/2003	VOC	59593	6/25/1993	Radionuclide
57094	8/11/2004	VOC	59593	8/13/1993	Metal
57594	4/12/1995	PCB	59593	8/13/1993	Radionuclide
57594	4/12/1995	Pesticide	59593	11/10/1993	Metal
57594	4/12/1995	Radionuclide	59593	11/10/1993	Radionuclide
57594	4/12/1995	SVOC	59593	3/14/1994	Metal
57594	4/12/1995	VOC	59593	3/14/1994	Radionuclide
57594	4/12/1995	WQP	59593	5/9/1994	Metal
5786	4/8/1987	Radionuclide	59593	5/9/1994	Radionuclide
5786	4/8/1987	VOC	59593	8/19/1994	Metal
5786	4/8/1987	WQP	59593	8/19/1994	Radionuclide
5786	12/15/1989	VOC	59593	10/24/1994	Metal
5786	2/22/1990	Radionuclide	59593	10/24/1994	Radionuclide
5786	2/22/1990	VOC	59593	1/11/1995	Metal
5786	2/22/1990	WQP	59593	1/11/1995	Radionuclide
5786	5/11/1990	VOC	59593	3/9/1995	Metal

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5786	5/11/1990	WQP	59593	3/9/1995	Radionuclide
5786	7/26/1990	Radionuclide	59593	6/14/1995	Metal
5786	7/26/1990	VOC	59593	6/14/1995	Radionuclide
5786	7/26/1990	WQP	59594	1/25/1995	Metal
5786	10/12/1990	VOC	59594	1/25/1995	Radionuclide
5786	3/29/1991	Radionuclide	59594	5/15/1995	Metal
5786	3/29/1991	VOC	59594	5/15/1995	Radionuclide
5786	3/29/1991	WQP	59594	7/28/2004	Metal
5786	5/22/1991	Radionuclide	59594	7/28/2004	Radionuclide
5786	5/22/1991	VOC	59694	3/8/1995	Metal
5786	5/22/1991	WQP	59694	3/8/1995	Radionuclide
5786	9/16/1991	Radionuclide	59694	5/23/1995	Metal
5786	9/16/1991	VOC	59694	5/23/1995	Radionuclide
5786	9/16/1991	WQP	59793	1/15/1995	Radionuclide
5786	12/14/1991	Radionuclide	59793	5/12/1995	Metal
5786	12/14/1991	VOC	59793	5/12/1995	Radionuclide
5786	12/14/1991	WQP	59894	3/8/1995	Metal
5786	2/18/1992	Metal	59894	3/8/1995	Radionuclide
5786	2/18/1992	Radionuclide	59894	5/16/1995	Metal
5786	2/18/1992	VOC	59894	5/16/1995	Radionuclide
5786	2/18/1992	WQP	59993	1/23/1995	Radionuclide
5786	4/29/1992	Metal	59993	5/11/1995	Metal
5786	4/29/1992	Radionuclide	60093	5/9/1995	Metal
5786	4/29/1992	VOC	60093	5/9/1995	Radionuclide
5786	4/29/1992	WQP	60293	1/22/1995	Metal
5786	3/17/1993	Radionuclide	60293	1/22/1995	Radionuclide
5786	3/17/1993	VOC	60293	4/20/1995	Metal
5786	3/17/1993	WQP	60293	4/20/1995	Radionuclide
5786	6/22/1993	Radionuclide	60393	5/10/1995	Metal
5786	6/22/1993	VOC	60393	5/10/1995	Radionuclide
5786	6/22/1993	WQP	60593	5/4/1995	Metal
5786	2/25/1994	Radionuclide	60593	5/4/1995	Radionuclide
5786	2/25/1994	VOC	60693	5/4/1995	Metal
5786	2/25/1994	WQP	60693	5/4/1995	Radionuclide
5786	5/19/1994	Radionuclide	60893	7/7/1993	Radionuclide
5786	5/19/1994	VOC	60893	1/26/1995	Metal
5786	5/19/1994	WQP	60893	1/26/1995	Radionuclide
5786	2/28/1995	Radionuclide	60893	4/20/1995	Metal
5786	2/28/1995	VOC	60893	4/20/1995	Radionuclide
5786	2/28/1995	WQP	60993	5/10/1995	Metal
5786	5/22/1995	Radionuclide	61093	7/13/1993	Radionuclide
5786	5/22/1995	VOC	61093	1/25/1995	Metal
5786	5/22/1995	WQP	61093	1/25/1995	Radionuclide
57894	1/22/1995	Metal	61093	4/24/1995	Metal
57894	1/22/1995	PCB	61093	4/24/1995	Radionuclide
57894	1/22/1995	Pesticide	61293	1/7/1995	Metal
57894	1/22/1995	Radionuclide	61293	1/7/1995	Radionuclide
57894	1/22/1995	SVOC	61293	8/2/2004	Metal
57894	1/22/1995	VOC	62793	7/13/1993	Radionuclide
57894	1/22/1995	WQP	62793	1/23/1995	Radionuclide
57894	4/25/1995	Metal	62793	5/11/1995	Metal
57894	4/25/1995	Radionuclide	62893	7/13/1993	Radionuclide

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57894	4/25/1995	SVOC	62893	1/18/1995	Metal
57894	4/25/1995	VOC	62893	1/18/1995	Radionuclide
57894	4/25/1995	WQP	62893	4/18/1995	Metal
57994	5/11/1995	VOC	62893	4/18/1995	Radionuclide
57994	5/29/2001	VOC	63193	7/12/1993	Radionuclide
57994	8/10/2004	VOC	63193	1/10/1995	Metal
58094	12/21/1994	PCB	63193	1/10/1995	Radionuclide
58094	12/21/1994	Pesticide	63193	4/17/1995	Metal
58094	12/21/1994	Radionuclide	63193	4/17/1995	Radionuclide
58094	12/21/1994	SVOC	63893	1/5/1995	Metal
58094	12/21/1994	VOC	63893	1/5/1995	Radionuclide
58094	12/21/1994	WQP	63893	4/18/1995	Metal
58094	4/26/1995	Metal	63893	4/18/1995	Radionuclide
58094	4/26/1995	Radionuclide	63993	1/5/1995	Metal
58094	4/26/1995	SVOC	63993	1/5/1995	Radionuclide
58094	4/26/1995	VOC	63993	4/18/1995	Metal
58094	4/26/1995	WQP	63993	4/18/1995	Radionuclide
58094	5/24/2001	VOC	64093	1/5/1995	Metal
58194	5/2/1995	Metal	64093	1/5/1995	Radionuclide
58194	5/2/1995	Radionuclide	64093	4/18/1995	Metal
58194	5/2/1995	SVOC	64093	4/18/1995	Radionuclide
58194	5/2/1995	VOC	7086	10/2/1986	Metal
58194	5/2/1995	WQP	7086	5/18/1987	Metal
58194	5/23/2001	VOC	7086	5/27/1987	Metal
58494	5/3/1995	Metal	7086	7/6/1987	Metal
58494	5/3/1995	Radionuclide	7086	7/6/1987	Radionuclide
58494	5/3/1995	SVOC	7086	12/8/1987	Metal
58494	5/3/1995	VOC	7086	12/8/1987	Radionuclide
58494	5/3/1995	WQP	7086	2/15/1988	Metal
58494	8/21/1997	VOC	7086	2/15/1988	Radionuclide
58494	6/6/2001	VOC	7086	4/7/1988	Metal
58494	7/10/2003	VOC	7086	4/7/1988	Radionuclide
58594	12/21/1994	PCB	7086	7/13/1988	Metal
58594	12/21/1994	Pesticide	7086	7/13/1988	Radionuclide
58594	12/21/1994	Radionuclide	7086	10/18/1988	Metal
58594	12/21/1994	SVOC	7086	1/16/1989	Metal
58594	12/21/1994	VOC	7086	1/16/1989	Radionuclide
58594	12/21/1994	WQP	7086	4/12/1989	Metal
58594	4/25/1995	Metal	7086	7/25/1989	Metal
58594	4/25/1995	Radionuclide	7086	7/25/1989	Radionuclide
58594	4/25/1995	SVOC	7086	11/30/1989	Metal
58594	4/25/1995	VOC	7086	2/22/1990	Metal
58594	4/25/1995	WQP	7086	5/24/1990	Metal
58594	8/21/1997	VOC	7086	7/20/1990	Metal
58594	5/21/2001	VOC	7086	7/20/1990	Radionuclide
58693	5/18/1993	Metal	7086	10/19/1990	Metal
58693	5/18/1993	Radionuclide	7086	10/19/1990	Radionuclide
58693	5/18/1993	VOC	7086	5/14/1991	Metal
59194	6/27/1995	Radionuclide	7086	5/14/1991	Radionuclide
59194	6/27/1995	SVOC	7086	9/6/1991	Metal
59194	6/27/1995	VOC	7086	9/6/1991	Radionuclide
59194	6/27/1995	WQP	7086	12/6/1991	Metal

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59194	7/31/2003	VOC	7086	12/6/1991	Radionuclide
59194	8/9/2004	VOC	7086	2/17/1992	Metal
59294	5/28/2003	VOC	7086	2/17/1992	Radionuclide
59294	8/3/2004	VOC	7086	4/28/1992	Metal
59393	3/29/1994	Metal	7086	4/28/1992	Radionuclide
59393	3/29/1994	Radionuclide	7086	8/14/1992	Metal
59393	3/29/1994	SVOC	7086	8/14/1992	Radionuclide
59393	3/29/1994	VOC	7086	11/6/1992	Metal
59393	3/29/1994	WQP	7086	11/6/1992	Radionuclide
59393	5/20/1994	Metal	7086	3/8/1993	Metal
59393	5/20/1994	Radionuclide	7086	3/8/1993	Radionuclide
59393	5/20/1994	VOC	7086	6/3/1993	Metal
59393	6/8/1994	Radionuclide	7086	6/3/1993	Radionuclide
59393	6/8/1994	SVOC	7086	9/20/1993	Metal
59393	6/8/1994	VOC	7086	9/20/1993	Radionuclide
59393	6/8/1994	WQP	7086	12/10/1993	Metal
59393	8/19/1994	SVOC	7086	12/10/1993	Radionuclide
59393	8/19/1994	VOC	7086	2/23/1994	Metal
59393	8/19/1994	WQP	7086	2/23/1994	Radionuclide
59393	10/26/1994	VOC	7086	5/16/1994	Metal
59393	10/26/1994	WQP	7086	5/16/1994	Radionuclide
59393	1/7/1995	Metal	7086	8/25/1994	Metal
59393	1/7/1995	Radionuclide	7086	8/25/1994	Radionuclide
59393	1/7/1995	VOC	7086	11/21/1994	Metal
59393	3/8/1995	Metal	7086	11/21/1994	Radionuclide
59393	3/8/1995	SVOC	7086	3/10/1995	Metal
59393	3/8/1995	VOC	7086	3/10/1995	Radionuclide
59393	3/8/1995	WQP	7086	11/9/1995	Metal
59393	4/26/1995	Metal	7086	11/9/1995	Radionuclide
59393	4/26/1995	Radionuclide	7086	4/26/1996	Metal
59393	4/26/1995	SVOC	7086	4/26/1996	Radionuclide
59393	4/26/1995	VOC	7086	7/18/1996	Metal
59393	4/26/1995	WQP	7086	7/18/1996	Radionuclide
59393	11/16/1995	Radionuclide	7086	11/25/1996	Metal
59393	11/16/1995	VOC	7086	11/25/1996	Radionuclide
59393	11/16/1995	WQP	7086	7/31/1997	Metal
59393	4/30/1996	Radionuclide	7086	2/27/1998	Metal
59393	4/30/1996	VOC	7086	7/28/1998	Metal
59393	4/30/1996	WQP	7086	7/28/1998	Radionuclide
59393	11/8/1996	Radionuclide	7086	2/8/1999	Radionuclide
59393	11/8/1996	VOC	7086	8/18/1999	Radionuclide
59393	11/8/1996	WQP	7086	2/7/2000	Metal
59393	5/29/2003	VOC	7086	2/7/2000	Radionuclide
59394	8/21/1997	VOC	7086	7/31/2000	Radionuclide
59493	6/25/1993	Metal	7086	2/23/2001	Metal
59493	6/25/1993	Radionuclide	7086	2/23/2001	Radionuclide
59493	6/25/1993	SVOC	7086	9/10/2001	Metal
59493	6/25/1993	VOC	7086	9/10/2001	Radionuclide
59493	6/25/1993	WQP	71494	3/14/1995	Metal
59493	8/11/1993	Metal	71494	3/14/1995	Radionuclide
59493	8/11/1993	Radionuclide	71494	5/16/1995	Metal
59493	8/11/1993	SVOC	71494	5/16/1995	Radionuclide

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59493	8/11/1993	VOC
59493	8/11/1993	WQP
59493	11/9/1993	Metal
59493	11/9/1993	Radionuclide
59493	11/9/1993	SVOC
59493	11/9/1993	VOC
59493	11/9/1993	WQP
59493	3/14/1994	Metal
59493	3/14/1994	Radionuclide
59493	3/14/1994	SVOC
59493	3/14/1994	VOC
59493	3/14/1994	WQP
59493	5/9/1994	Metal
59493	5/9/1994	Radionuclide
59493	5/9/1994	SVOC
59493	5/9/1994	VOC
59493	5/9/1994	WQP
59493	8/19/1994	Metal
59493	8/19/1994	Radionuclide
59493	8/19/1994	SVOC
59493	8/19/1994	VOC
59493	8/19/1994	WQP
59493	10/21/1994	Metal
59493	10/21/1994	Radionuclide
59493	10/21/1994	SVOC
59493	10/21/1994	VOC
59493	10/21/1994	WQP
59493	1/4/1995	PCB
59493	1/4/1995	Pesticide
59493	1/4/1995	Radionuclide
59493	1/4/1995	SVOC
59493	1/4/1995	VOC
59493	1/4/1995	WQP
59493	3/9/1995	Metal
59493	3/9/1995	Radionuclide
59493	3/9/1995	SVOC
59493	3/9/1995	VOC
59493	3/9/1995	WQP
59493	6/9/1995	Metal
59493	6/9/1995	Radionuclide
59493	6/9/1995	SVOC
59493	6/9/1995	VOC
59493	6/9/1995	WQP
59493	7/31/2003	VOC
59593	6/25/1993	Metal
59593	6/25/1993	Radionuclide
59593	6/25/1993	SVOC
59593	6/25/1993	VOC
59593	6/25/1993	WQP
59593	8/13/1993	Metal
59593	8/13/1993	Radionuclide
59593	8/13/1993	SVOC
P416689	2/16/1994	Metal
P416689	4/29/1994	Metal
P416689	8/19/1994	Metal
P416689	4/25/1995	Metal
P416689	10/17/1995	Radionuclide
P416689	2/19/1996	Radionuclide
P416689	4/30/1996	Radionuclide
P416689	7/17/1996	Radionuclide
P416689	1/28/1997	Metal
P416689	6/3/1997	Metal
P416689	12/3/1997	Metal
P416689	4/29/1998	Metal
P416689	10/19/1998	Metal
P416689	4/26/1999	Metal
P416689	10/19/1999	Metal
P416689	5/8/2000	Metal
P416689	5/8/2000	Radionuclide
P416689	12/12/2000	Metal
P416689	12/12/2000	Radionuclide
P416689	4/9/2001	Metal
P416689	4/9/2001	Radionuclide
P416689	12/12/2001	Metal
P416689	12/12/2001	Radionuclide
P416689	5/8/2002	Radionuclide
P416689	5/16/2002	Metal
P416689	10/22/2002	Metal
P416689	10/31/2002	Radionuclide
P416689	5/6/2003	Metal
P416689	5/6/2003	Radionuclide
P416689	6/10/2003	Metal
P416689	7/9/2003	Metal
P416689	3/16/2004	Metal
P416689	4/19/2004	Metal
P416689	5/25/2004	Metal

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59593	8/13/1993	VOC
59593	8/13/1993	WQP
59593	11/10/1993	Metal
59593	11/10/1993	Radionuclide
59593	11/10/1993	SVOC
59593	11/10/1993	VOC
59593	11/10/1993	WQP
59593	3/14/1994	Metal
59593	3/14/1994	Radionuclide
59593	3/14/1994	SVOC
59593	3/14/1994	VOC
59593	3/14/1994	WQP
59593	5/9/1994	Metal
59593	5/9/1994	Radionuclide
59593	5/9/1994	SVOC
59593	5/9/1994	VOC
59593	5/9/1994	WQP
59593	8/19/1994	Metal
59593	8/19/1994	Radionuclide
59593	8/19/1994	SVOC
59593	8/19/1994	VOC
59593	8/19/1994	WQP
59593	10/24/1994	Metal
59593	10/24/1994	Radionuclide
59593	10/24/1994	SVOC
59593	10/24/1994	VOC
59593	10/24/1994	WQP
59593	1/11/1995	Radionuclide
59593	1/11/1995	WQP
59593	3/9/1995	Metal
59593	3/9/1995	Radionuclide
59593	3/9/1995	SVOC
59593	3/9/1995	VOC
59593	3/9/1995	WQP
59593	6/14/1995	Metal
59593	6/14/1995	Radionuclide
59593	6/14/1995	SVOC
59593	6/14/1995	VOC
59593	6/14/1995	WQP
59593	5/29/2003	VOC
59594	1/25/1995	PCB
59594	1/25/1995	Pesticide
59594	1/25/1995	Radionuclide
59594	1/25/1995	SVOC
59594	1/25/1995	VOC
59594	1/25/1995	WQP
59594	5/15/1995	Radionuclide
59594	5/15/1995	SVOC
59594	5/15/1995	VOC
59594	5/15/1995	WQP
59594	7/31/2003	VOC
59694	3/8/1995	PCB

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59694	3/8/1995	Pesticide
59694	3/8/1995	Radionuclide
59694	3/8/1995	SVOC
59694	3/8/1995	VOC
59694	5/23/1995	PCB
59694	5/23/1995	Pesticide
59694	5/23/1995	Radionuclide
59694	5/23/1995	SVOC
59694	5/23/1995	VOC
59694	5/23/1995	WQP
59694	7/31/2003	VOC
59793	1/15/1995	Radionuclide
59793	1/15/1995	VOC
59793	5/12/1995	Metal
59793	5/12/1995	Radionuclide
59793	5/12/1995	SVOC
59793	5/12/1995	VOC
59793	5/12/1995	WQP
59793	5/17/2001	VOC
59794	7/10/2003	VOC
59894	3/8/1995	PCB
59894	3/8/1995	Pesticide
59894	3/8/1995	Radionuclide
59894	3/8/1995	SVOC
59894	3/8/1995	VOC
59894	3/8/1995	WQP
59894	5/16/1995	Radionuclide
59894	5/16/1995	SVOC
59894	5/16/1995	VOC
59894	5/16/1995	WQP
59993	7/6/1993	Radionuclide
59993	7/6/1993	VOC
59993	1/23/1995	Radionuclide
59993	1/23/1995	VOC
59993	6/7/2001	VOC
60093	7/6/1993	VOC
60093	5/9/1995	Metal
60093	5/9/1995	Radionuclide
60093	5/9/1995	SVOC
60093	5/9/1995	VOC
60093	5/9/1995	WQP
60293	7/6/1993	Metal
60293	7/6/1993	PCB
60293	7/6/1993	Pesticide
60293	7/6/1993	Radionuclide
60293	7/6/1993	SVOC
60293	7/6/1993	VOC
60293	7/6/1993	WQP
60293	1/22/1995	Metal
60293	1/22/1995	PCB
60293	1/22/1995	Pesticide
60293	1/22/1995	Radionuclide

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60293	1/22/1995	SVOC
60293	1/22/1995	VOC
60293	1/22/1995	WQP
60293	4/20/1995	Metal
60293	4/20/1995	Radionuclide
60293	4/20/1995	SVOC
60293	4/20/1995	VOC
60293	4/20/1995	WQP
60393	5/10/1995	Radionuclide
60393	5/10/1995	VOC
60493	7/13/1993	VOC
60493	7/29/2003	VOC
60593	7/7/1993	VOC
60593	5/4/1995	Metal
60593	5/4/1995	Radionuclide
60593	5/4/1995	SVOC
60593	5/4/1995	VOC
60593	5/4/1995	WQP
60693	7/7/1993	VOC
60693	5/4/1995	Metal
60693	5/4/1995	Radionuclide
60693	5/4/1995	SVOC
60693	5/4/1995	VOC
60693	5/4/1995	WQP
60893	7/7/1993	VOC
60893	1/26/1995	Metal
60893	1/26/1995	Radionuclide
60893	1/26/1995	SVOC
60893	1/26/1995	VOC
60893	4/20/1995	Metal
60893	4/20/1995	Radionuclide
60893	4/20/1995	SVOC
60893	4/20/1995	VOC
60893	4/20/1995	WQP
60993	5/10/1995	VOC
61093	7/13/1993	Metal
61093	7/13/1993	PCB
61093	7/13/1993	Pesticide
61093	7/13/1993	Radionuclide
61093	7/13/1993	SVOC
61093	7/13/1993	VOC
61093	7/13/1993	WQP
61093	1/25/1995	Metal
61093	1/25/1995	PCB
61093	1/25/1995	Pesticide
61093	1/25/1995	Radionuclide
61093	1/25/1995	SVOC
61093	1/25/1995	VOC
61093	1/25/1995	WQP
61093	4/24/1995	Metal
61093	4/24/1995	Radionuclide
61093	4/24/1995	SVOC

Table 2
Sampling and Analytical Summary for OLF Groundwater

61093	4/24/1995	VOC
61093	4/24/1995	WQP
61093	6/23/2004	VOC
61293	1/7/1995	Radionuclide
61293	1/7/1995	VOC
61293	5/22/1995	SVOC
61293	5/22/1995	VOC
61293	5/22/1995	WQP
61293	5/2/2003	VOC
61293	8/2/2004	Radionuclide
61293	8/2/2004	VOC
62793	7/13/1993	VOC
62793	1/23/1995	Radionuclide
62793	1/23/1995	VOC
62793	5/11/1995	VOC
62793	5/29/2001	VOC
62893	7/13/1993	VOC
62893	1/18/1995	Metal
62893	1/18/1995	Radionuclide
62893	2/1/1995	VOC
62893	4/18/1995	Metal
62893	4/18/1995	Radionuclide
62893	4/18/1995	SVOC
62893	4/18/1995	VOC
62893	4/18/1995	WQP
62893	8/21/1997	VOC
62893	5/29/2001	Radionuclide
62893	5/29/2001	VOC
62893	5/27/2003	VOC
63193	7/12/1993	Metal
63193	7/12/1993	PCB
63193	7/12/1993	Pesticide
63193	7/12/1993	Radionuclide
63193	7/12/1993	SVOC
63193	7/12/1993	VOC
63193	7/12/1993	WQP
63193	1/10/1995	Radionuclide
63193	1/10/1995	SVOC
63193	1/10/1995	VOC
63193	1/10/1995	WQP
63193	4/17/1995	Metal
63193	4/17/1995	Radionuclide
63193	4/17/1995	SVOC
63193	4/17/1995	VOC
63193	4/17/1995	WQP
63193	8/21/1997	VOC
63193	5/21/2001	VOC
63193	5/28/2003	VOC
63893	1/5/1995	PCB
63893	1/5/1995	Pesticide
63893	1/5/1995	Radionuclide
63893	1/5/1995	SVOC

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Table 2
Sampling and Analytical Summary for OLF Groundwater

63893	1/5/1995	VOC
63893	1/5/1995	WQP
63893	4/18/1995	Metal
63893	4/18/1995	Radionuclide
63893	4/18/1995	SVOC
63893	4/18/1995	VOC
63893	4/18/1995	WQP
63993	1/5/1995	PCB
63993	1/5/1995	Pesticide
63993	1/5/1995	Radionuclide
63993	1/5/1995	SVOC
63993	1/5/1995	VOC
63993	1/5/1995	WQP
63993	4/18/1995	Metal
63993	4/18/1995	Radionuclide
63993	4/18/1995	SVOC
63993	4/18/1995	VOC
63993	4/18/1995	WQP
64093	1/5/1995	PCB
64093	1/5/1995	Pesticide
64093	1/5/1995	Radionuclide
64093	1/5/1995	SVOC
64093	1/5/1995	VOC
64093	1/5/1995	WQP
64093	4/18/1995	Metal
64093	4/18/1995	Radionuclide
64093	4/18/1995	SVOC
64093	4/18/1995	VOC
64093	4/18/1995	WQP
7086	10/2/1986	Metal
7086	10/2/1986	PCB
7086	10/2/1986	Pesticide
7086	10/2/1986	Radionuclide
7086	10/2/1986	VOC
7086	10/2/1986	WQP
7086	5/18/1987	Radionuclide
7086	5/18/1987	VOC
7086	5/18/1987	WQP
7086	5/27/1987	Radionuclide
7086	5/27/1987	VOC
7086	5/27/1987	WQP
7086	7/6/1987	VOC
7086	7/6/1987	WQP
7086	12/8/1987	VOC
7086	12/8/1987	WQP
7086	2/15/1988	VOC
7086	2/15/1988	WQP
7086	4/7/1988	VOC
7086	4/7/1988	WQP
7086	7/13/1988	WQP
7086	10/18/1988	VOC
7086	10/18/1988	WQP

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Table 2
Sampling and Analytical Summary for OLF Groundwater

7086	1/16/1989	VOC
7086	1/16/1989	WQP
7086	4/12/1989	VOC
7086	4/12/1989	WQP
7086	7/25/1989	VOC
7086	7/25/1989	WQP
7086	11/30/1989	Radionuclide
7086	11/30/1989	VOC
7086	11/30/1989	WQP
7086	2/22/1990	Radionuclide
7086	2/22/1990	VOC
7086	2/22/1990	WQP
7086	5/24/1990	Radionuclide
7086	5/24/1990	VOC
7086	5/24/1990	WQP
7086	7/20/1990	Radionuclide
7086	7/20/1990	VOC
7086	7/20/1990	WQP
7086	10/19/1990	Radionuclide
7086	10/19/1990	VOC
7086	10/19/1990	WQP
7086	5/14/1991	Radionuclide
7086	5/14/1991	VOC
7086	5/14/1991	WQP
7086	9/6/1991	Metal
7086	9/6/1991	Radionuclide
7086	9/6/1991	VOC
7086	9/6/1991	WQP
7086	12/6/1991	Metal
7086	12/6/1991	Radionuclide
7086	12/6/1991	VOC
7086	12/6/1991	WQP
7086	2/17/1992	Metal
7086	2/17/1992	Radionuclide
7086	2/17/1992	VOC
7086	2/17/1992	WQP
7086	4/28/1992	Metal
7086	4/28/1992	Radionuclide
7086	4/28/1992	VOC
7086	4/28/1992	WQP
7086	8/14/1992	Metal
7086	8/14/1992	Radionuclide
7086	8/14/1992	VOC
7086	8/14/1992	WQP
7086	11/6/1992	Metal
7086	11/6/1992	Radionuclide
7086	11/6/1992	VOC
7086	11/6/1992	WQP
7086	3/8/1993	Radionuclide
7086	3/8/1993	VOC
7086	3/8/1993	WQP
7086	6/3/1993	Radionuclide

Table 2
Sampling and Analytical Summary for OLF Groundwater

7086	6/3/1993	VOC
7086	6/3/1993	WQP
7086	9/20/1993	Radionuclide
7086	9/20/1993	VOC
7086	9/20/1993	WQP
7086	12/10/1993	Radionuclide
7086	12/10/1993	VOC
7086	12/10/1993	WQP
7086	2/23/1994	Radionuclide
7086	2/23/1994	VOC
7086	2/23/1994	WQP
7086	5/16/1994	Radionuclide
7086	5/16/1994	VOC
7086	5/16/1994	WQP
7086	8/25/1994	Radionuclide
7086	8/25/1994	VOC
7086	8/25/1994	WQP
7086	11/21/1994	Radionuclide
7086	11/21/1994	VOC
7086	11/21/1994	WQP
7086	3/10/1995	Radionuclide
7086	3/10/1995	VOC
7086	3/10/1995	WQP
7086	11/9/1995	Radionuclide
7086	11/9/1995	VOC
7086	11/9/1995	WQP
7086	4/26/1996	Radionuclide
7086	4/26/1996	VOC
7086	4/26/1996	WQP
7086	7/18/1996	Radionuclide
7086	7/18/1996	VOC
7086	7/18/1996	WQP
7086	11/25/1996	Radionuclide
7086	11/25/1996	VOC
7086	7/31/1997	Radionuclide
7086	7/31/1997	VOC
7086	7/31/1997	WQP
7086	2/27/1998	Radionuclide
7086	2/27/1998	VOC
7086	2/27/1998	WQP
7086	7/28/1998	VOC
7086	7/28/1998	WQP
7086	2/8/1999	Metal
7086	2/8/1999	VOC
7086	2/8/1999	WQP
7086	8/18/1999	Metal
7086	8/19/1999	VOC
7086	8/19/1999	WQP
7086	2/7/2000	VOC
7086	2/7/2000	WQP
7086	7/31/2000	Metal
7086	7/31/2000	Radionuclide

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Table 2
Sampling and Analytical Summary for OLF Groundwater

7086	7/31/2000	VOC
7086	7/31/2000	WQP
7086	2/23/2001	VOC
7086	2/23/2001	WQP
7086	9/10/2001	VOC
7086	9/10/2001	WQP
7086	2/7/2002	Metal
7086	2/7/2002	Radionuclide
7086	2/7/2002	VOC
7086	2/7/2002	WQP
7086	3/11/2002	Metal
7086	4/15/2002	Metal
7086	5/16/2002	Metal
7086	9/4/2002	Metal
7086	9/4/2002	Radionuclide
7086	9/4/2002	VOC
7086	9/4/2002	WQP
7086	2/11/2003	Metal
7086	2/11/2003	Radionuclide
7086	2/11/2003	VOC
7086	2/11/2003	WQP
7086	8/26/2003	Metal
7086	8/26/2003	Radionuclide
7086	8/26/2003	VOC
7086	8/26/2003	WQP
7086	9/30/2003	Metal
7086	10/23/2003	Metal
7086	10/23/2003	Radionuclide
7086	10/23/2003	VOC
7086	5/12/2004	Metal
7086	5/12/2004	Radionuclide
7086	5/12/2004	VOC
71494	3/14/1995	PCB
71494	3/14/1995	Pesticide
71494	3/14/1995	Radionuclide
71494	3/14/1995	SVOC
71494	3/14/1995	VOC
71494	3/14/1995	WQP
71494	5/16/1995	PCB
71494	5/16/1995	Pesticide
71494	5/16/1995	Radionuclide
71494	5/16/1995	SVOC
71494	5/16/1995	VOC
71494	5/16/1995	WQP
71494	8/12/2003	VOC
P416689	11/22/1993	Radionuclide
P416689	11/22/1993	SVOC
P416689	11/22/1993	VOC
P416689	11/22/1993	WQP
P416689	2/16/1994	VOC
P416689	4/29/1994	Metal
P416689	4/29/1994	Radionuclide

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Table 2
Sampling and Analytical Summary for OLF Groundwater

P416689	4/29/1994	VOC
P416689	8/19/1994	Radionuclide
P416689	8/19/1994	VOC
P416689	11/8/1994	Radionuclide
P416689	11/8/1994	VOC
P416689	11/8/1994	WQP
P416689	1/31/1995	Radionuclide
P416689	1/31/1995	VOC
P416689	1/31/1995	WQP
P416689	4/25/1995	Metal
P416689	4/25/1995	Radionuclide
P416689	4/25/1995	VOC
P416689	8/16/1995	Radionuclide
P416689	8/16/1995	VOC
P416689	8/16/1995	WQP
P416689	10/17/1995	Radionuclide
P416689	10/17/1995	VOC
P416689	2/19/1996	Radionuclide
P416689	2/19/1996	VOC
P416689	4/30/1996	Radionuclide
P416689	4/30/1996	VOC
P416689	7/17/1996	Radionuclide
P416689	7/17/1996	VOC
P416689	7/17/1996	WQP
P416689	1/28/1997	VOC
P416689	6/3/1997	VOC
P416689	12/3/1997	VOC
P416689	3/12/1998	VOC
P416689	4/29/1998	VOC
P416689	10/19/1998	VOC
P416689	4/26/1999	Radionuclide
P416689	4/26/1999	VOC
P416689	10/19/1999	Radionuclide
P416689	10/19/1999	VOC
P416689	5/8/2000	Radionuclide
P416689	5/8/2000	VOC
P416689	12/6/2000	VOC
P416689	12/29/2000	Radionuclide
P416689	4/9/2001	VOC
P416689	4/30/2001	Radionuclide
P416689	12/4/2001	VOC
P416689	4/29/2002	VOC
P416689	6/12/2002	Radionuclide
P416689	10/14/2002	VOC
P416689	11/21/2002	Radionuclide
P416689	4/28/2003	VOC
P416689	5/6/2003	Radionuclide
P416689	10/22/2003	VOC
P416689	4/13/2004	VOC
P416689	6/22/2004	VOC
P416689	7/20/2004	VOC
P416689	8/17/2004	VOC

Table 3
Sampling and Analytical Summary for OLF Surface Water

Upgradient Woman Creek						Downgradient Woman Creek						South Interceptor Ditch					
Total Concentrations			Dissolved Concentrations			Total Concentrations			Dissolved Concentrations			Total Concentrations			Dissolved Concentrations		
Location Code	Collection Date	Analyte Group	Location Code	Collection Date	Analyte Group	Location C	Collection Date	Analyte Group	Location Code	Collection Date	Analyte Group	Location Code	Collection Date	Analyte Group	Location Code	Collection Date	Analyte Group
SW039	06/27/88	Metal	SW039	06/27/88	Metal	SW032	08/20/86	Pesticide	SW032	08/20/86	Metal	INT. DITCH	8/8/1990	Metal	INT. DITCH	8/8/1990	Metal
SW039	06/27/88	Radionuclide	SW039	06/27/88	Radionuclide	SW032	08/20/86	Radionuclide	SW032	05/26/87	Metal	INT. DITCH	8/8/1990	Radionuclide	INT. DITCH	8/8/1990	Radionuclide
SW039	06/27/88	VOC	SW039	04/06/89	Metal	SW032	08/20/86	SVOC	SW032	07/30/87	Metal	INT. DITCH	8/8/1990	VOC	SW036	8/20/1986	Metal
SW039	06/27/88	WQP	SW039	04/06/89	Radionuclide	SW032	08/20/86	VOC	SW032	06/21/88	Metal	INT. DITCH	8/8/1990	WQP	SW036	6/27/1988	Metal
SW039	04/06/89	Metal	SW039	05/26/89	Metal	SW032	08/20/86	WQP	SW032	06/21/88	Radionuclide	INT. DITCH	8/24/1992	VOC	SW036	6/27/1988	Radionuclide
SW039	04/06/89	Pesticide	SW039	06/16/89	Metal	SW032	05/26/87	Radionuclide	SW032	04/05/89	Metal	SW036	8/20/1986	Pesticide	SW036	4/3/1989	Metal
SW039	04/06/89	Radionuclide	SW039	11/17/89	Metal	SW032	05/26/87	VOC	SW032	04/05/89	Radionuclide	SW036	8/20/1986	Radionuclide	SW036	4/3/1989	Radionuclide
SW039	04/06/89	SVOC	SW039	12/20/89	Metal	SW032	05/26/87	WQP	SW032	06/21/89	Metal	SW036	8/20/1986	SVOC	SW036	6/28/1989	Metal
SW039	04/06/89	VOC	SW039	01/17/90	Metal	SW032	07/30/87	VOC	SW032	07/19/89	Metal	SW036	8/20/1986	VOC	SW036	9/22/1989	Metal
SW039	04/06/89	WQP	SW039	02/08/90	Metal	SW032	07/30/87	WQP	SW032	08/04/89	Metal	SW036	8/20/1986	WQP	SW036	10/19/1989	Metal
SW039	05/26/89	Metal	SW039	03/21/90	Metal	SW032	11/11/87	VOC	SW032	10/13/89	Metal	SW036	6/27/1988	Metal	SW036	11/9/1989	Metal
SW039	05/26/89	Pesticide	SW039	04/12/90	Metal	SW032	06/21/88	Metal	SW032	12/15/89	Metal	SW036	6/27/1988	Radionuclide	SW036	12/14/1989	Metal
SW039	05/26/89	Radionuclide	SW039	04/12/90	Radionuclide	SW032	06/21/88	Radionuclide	SW032	01/16/90	Metal	SW036	6/27/1988	VOC	SW036	1/12/1990	Metal
SW039	05/26/89	SVOC	SW039	05/09/90	Metal	SW032	06/21/88	VOC	SW032	03/23/90	Metal	SW036	6/27/1988	WQP	SW036	2/9/1990	Metal
SW039	05/26/89	VOC	SW039	06/07/90	Metal	SW032	06/21/88	WQP	SW032	04/11/90	Metal	SW036	4/3/1989	Metal	SW036	3/14/1990	Metal
SW039	05/26/89	WQP	SW039	07/16/90	Radionuclide	SW032	04/05/89	Metal	SW032	04/11/90	Radionuclide	SW036	4/3/1989	Pesticide	SW036	4/12/1990	Metal
SW039	06/16/89	Metal	SW039	08/15/90	Radionuclide	SW032	04/05/89	Pesticide	SW032	05/10/90	Metal	SW036	4/3/1989	Radionuclide	SW036	4/12/1990	Radionuclide
SW039	06/16/89	Radionuclide	SW039	09/13/90	Metal	SW032	04/05/89	Radionuclide	SW032	07/16/90	Radionuclide	SW036	4/3/1989	SVOC	SW036	5/14/1990	Metal
SW039	06/16/89	VOC	SW039	10/02/90	Metal	SW032	04/05/89	SVOC	SW032	08/09/90	Metal	SW036	4/3/1989	VOC	SW036	6/7/1990	Metal
SW039	06/16/89	WQP	SW039	11/08/90	Metal	SW032	04/05/89	VOC	SW032	09/13/90	Metal	SW036	4/3/1989	WQP	SW036	8/8/1990	Metal
SW039	11/17/89	Metal	SW039	11/08/90	Radionuclide	SW032	04/05/89	WQP	SW032	10/04/90	Metal	SW036	5/24/1989	Pesticide	SW036	8/8/1990	Radionuclide
SW039	11/17/89	Radionuclide	SW039	12/04/90	Metal	SW032	05/24/89	Pesticide	SW032	11/07/90	Metal	SW036	5/24/1989	Radionuclide	SW036	11/20/1990	Metal
SW039	11/17/89	VOC	SW039	12/04/90	Radionuclide	SW032	05/24/89	Radionuclide	SW032	11/07/90	Radionuclide	SW036	5/24/1989	WQP	SW036	11/20/1990	Radionuclide
SW039	12/20/89	Metal	SW039	03/28/91	Metal	SW032	05/24/89	WQP	SW032	12/04/90	Metal	SW036	6/28/1989	Metal	SW036	3/15/1991	Metal
SW039	12/20/89	Radionuclide	SW039	03/28/91	Radionuclide	SW032	06/21/89	Metal	SW032	12/04/90	Radionuclide	SW036	6/28/1989	Radionuclide	SW036	3/15/1991	Radionuclide
SW039	12/20/89	VOC	SW039	04/01/91	Metal	SW032	06/21/89	Radionuclide	SW032	03/13/91	Metal	SW036	6/28/1989	VOC	SW036	4/8/1991	Metal
SW039	12/20/89	WQP	SW039	04/01/91	Radionuclide	SW032	06/21/89	VOC	SW032	03/13/91	Radionuclide	SW036	6/28/1989	WQP	SW036	4/8/1991	Radionuclide
SW039	01/17/90	Metal	SW039	05/03/91	Metal	SW032	06/21/89	WQP	SW032	04/04/91	Metal	SW036	9/22/1989	Metal	SW036	5/16/1991	Metal
SW039	01/17/90	Radionuclide	SW039	05/03/91	Radionuclide	SW032	07/19/89	Metal	SW032	04/04/91	Radionuclide	SW036	9/22/1989	Radionuclide	SW036	5/16/1991	Radionuclide
SW039	01/17/90	VOC	SW039	06/04/91	Metal	SW032	07/19/89	Radionuclide	SW032	05/09/91	Metal	SW036	9/22/1989	VOC	SW036	8/13/1991	Metal
SW039	01/17/90	WQP	SW039	06/04/91	Radionuclide	SW032	07/19/89	VOC	SW032	05/09/91	Radionuclide	SW036	9/22/1989	WQP	SW036	8/13/1991	Radionuclide
SW039	02/08/90	Metal	SW039	07/08/91	Metal	SW032	07/19/89	WQP	SW032	06/13/91	Metal	SW036	10/19/1989	Metal	SW036	11/7/1991	Metal
SW039	02/08/90	Radionuclide	SW039	07/08/91	Radionuclide	SW032	08/04/89	Metal	SW032	06/13/91	Radionuclide	SW036	10/19/1989	Radionuclide	SW036	4/8/1992	Metal
SW039	02/08/90	VOC	SW039	08/05/91	Metal	SW032	08/04/89	Radionuclide	SW032	07/10/91	Metal	SW036	10/19/1989	SVOC	SW036	8/25/1992	Metal
SW039	02/08/90	WQP	SW039	09/05/91	Metal	SW032	08/04/89	WQP	SW032	07/10/91	Radionuclide	SW036	10/19/1989	VOC	SW038	11/5/1990	Metal
SW039	03/21/90	Metal	SW039	10/02/91	Metal	SW032	09/19/89	Metal	SW032	08/07/91	Metal	SW036	11/9/1989	Metal	SW038	11/5/1990	Radionuclide
SW039	03/21/90	Radionuclide	SW039	11/18/91	Metal	SW032	09/19/89	Radionuclide	SW032	08/07/91	Radionuclide	SW036	11/9/1989	VOC	SW038	12/11/1990	Metal
SW039	03/21/90	VOC	SW039	04/15/92	Metal	SW032	09/19/89	VOC	SW032	09/26/91	Metal	SW036	12/14/1989	Metal	SW038	12/11/1990	Radionuclide
SW039	03/21/90	WQP	SW040	07/30/87	Metal	SW032	09/19/89	WQP	SW032	10/10/91	Metal	SW036	12/14/1989	Radionuclide	SW038	3/28/1991	Metal
SW039	04/12/90		SW040	11/04/92	Metal	SW032	10/13/89	Metal	SW032	11/13/91	Metal	SW036	12/14/1989	WQP	SW038	3/28/1991	Radionuclide
SW039	04/12/90	Metal	SW040	11/04/92	Radionuclide	SW032	10/13/89	Pesticide	SW032	01/15/92	Metal	SW036	1/12/1990	Metal	SW038	4/9/1991	Metal
SW039	04/12/90	Pesticide	SW040	03/24/93	Metal	SW032	10/13/89	Radionuclide	SW032	01/15/92	Radionuclide	SW036	1/12/1990	Radionuclide	SW038	4/9/1991	Radionuclide
SW039	04/12/90	Radionuclide	SW040	03/24/93	Radionuclide	SW032	10/13/89	SVOC	SW032	04/02/92	Metal	SW036	1/12/1990	VOC	SW038	5/16/1991	Metal
SW039	04/12/90	SVOC	SW041	07/29/87	Metal	SW032	10/13/89	VOC	SW033	07/01/88	Metal	SW036	1/12/1990	WQP	SW038	5/16/1991	Radionuclide
SW039	04/12/90	VOC	SW041	03/01/89	Metal	SW032	12/15/89	Metal	SW033	07/01/88	Radionuclide	SW036	2/9/1990	Radionuclide	SW038	6/20/1991	Metal
SW039	04/12/90	WQP	SW041	03/01/89	Radionuclide	SW032	12/15/89	Radionuclide	SW033	04/04/89	Metal	SW036	2/9/1990	VOC	SW038	6/20/1991	Radionuclide
SW039	05/09/90	Metal	SW041	05/26/89	Metal	SW032	12/15/89	VOC	SW033	04/04/89	Radionuclide	SW036	2/9/1990	WQP	SW038	7/25/1991	Metal
SW039	05/09/90	Radionuclide	SW041	06/16/89	Metal	SW032	12/15/89	WQP	SW033	06/21/89	Metal	SW036	3/14/1990	Metal	SW038	7/25/1991	Radionuclide
SW039	05/09/90	VOC	SW041	11/20/89	Metal	SW032	01/16/90	Metal	SW033	09/19/89	Metal	SW036	3/14/1990	Radionuclide	SW038	8/28/1991	Metal
SW039	05/09/90	WQP	SW041	12/05/89	Metal	SW032	01/16/90	Radionuclide	SW033	10/13/89	Metal	SW036	3/14/1990	VOC	SW038	9/18/1991	Metal
SW039	06/07/90	Metal	SW041	01/04/90	Metal	SW032	01/16/90	VOC	SW033	12/15/89	Metal	SW036	4/12/1990	Pesticide	SW038	10/23/1991	Metal
SW039	06/07/90	Radionuclide	SW041	02/06/90	Metal	SW032	01/16/90	WQP	SW033	01/16/90	Metal	SW036	4/12/1990	Radionuclide	SW038	11/7/1991	Metal
SW039	06/07/90	VOC	SW041	02/06/90	Radionuclide	SW032	02/20/90	Radionuclide	SW033	03/23/90	Metal	SW036	5/14/1990	Metal	SW038	1/20/1992	Metal
SW039	06/07/90	WQP	SW041	03/21/90	Metal	SW032	02/20/90	VOC	SW033	04/11/90	Metal	SW036	5/14/1990	Radionuclide	SW038	4/7/1992	Metal
SW039	07/16/90	Radionuclide	SW041	04/05/90	Metal	SW032	03/23/90	Metal	SW033	04/11/90	Radionuclide	SW036	5/14/1990	VOC	SW038	8/10/1992	Metal
SW039	07/16/90	VOC	SW041	05/02/90	Metal	SW032	03/23/90	Radionuclide	SW033	05/10/90	Metal	SW036	5/14/1990	WQP	SW129	11/5/1990	Metal
SW039	07/16/90	WQP	SW041	06/04/90	Metal	SW032	03/23/90	VOC	SW033	06/07/90	Metal	SW036	6/7/1990	Metal	SW129	11/5/1990	Radionuclide
SW039	08/15/90	Radionuclide	SW041	07/05/90	Metal	SW032	04/11/90		SW033	07/16/90	Radionuclide	SW036	6/7/1990	Radionuclide	SW129	12/6/1990	Metal
SW039	09/13/90	Metal	SW041	07/05/90	Radionuclide	SW032	04/11/90	Metal	SW033	08/14/90	Radionuclide	SW036	6/7/1990	VOC	SW129	12/6/1990	Radionuclide
SW039	09/13/90	Radionuclide	SW041	08/06/90	Metal	SW032	04/11/90	Pesticide	SW033	09/13/90	Metal	SW036	6/7/1990	WQP	SW129	3/28/1991	Metal
SW039	09/13/90	WQP	SW041	08/06/90	Radionuclide	SW032	04/11/90	SVOC	SW033	10/04/90	Metal	SW036	8/8/1990	Metal	SW129	3/28/1991	Radionuclide
SW039	10/02/90	Metal	SW041	09/05/90	Metal	SW032	04/11/90	VOC	SW033	11/07/90	Metal	SW036	8/8/1990	Radionuclide	SW129	4/9/1991	Metal
SW039	10/02/90	Pesticide	SW041	10/02/90	Metal	SW032	04/11/90	WQP	SW033	11/07/90	Radionuclide	SW036	8/8/1990	VOC	SW129	4/9/1991	Radionuclide
SW039	10/02/90	SVOC	SW041	12/04/90	Metal	SW032	05/10/90	Metal	SW033	12/04/90	Metal	SW036	8/8/1990	WQP	SW129	5/16/1991	Metal
SW039	10/02/90	VOC	SW041	12/04/90	Radionuclide	SW032	05/10/90	Radionuclide	SW033	12/04/90	Radionuclide	SW036	11/20/1990	Metal	SW129	5/16/1991	Radionuclide
SW039	10/02/90	WQP	SW041	05/03/91	Metal	SW032	05/10/90	VOC	SW033	03/08/91	Metal	SW036	11/20/1990	Radionuclide	SW129	6/26/1991	Metal
SW039	11/08/90	Metal	SW041	05/03/91	Radionuclide	SW032	05/10/90	WQP	SW033	04/04/91	Metal	SW036	11/20/1990	VOC	SW129	6/26/1991	Radionuclide

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Table 3
Sampling and Analytical Summary for OLF Surface Water

SW039	11/08/90	Radionuclide
SW039	11/08/90	VOC
SW039	11/08/90	WQP
SW039	12/04/90	Metal
SW039	12/04/90	Radionuclide
SW039	12/04/90	VOC
SW039	12/04/90	WQP
SW039	03/28/91	Metal
SW039	03/28/91	Radionuclide
SW039	03/28/91	VOC
SW039	03/28/91	WQP
SW039	04/01/91	Metal
SW039	04/01/91	Pesticide
SW039	04/01/91	Radionuclide
SW039	04/01/91	SVOC
SW039	04/01/91	VOC
SW039	04/01/91	WQP
SW039	05/03/91	Metal
SW039	05/03/91	Radionuclide
SW039	05/03/91	VOC
SW039	05/03/91	WQP
SW039	06/04/91	Metal
SW039	06/04/91	Radionuclide
SW039	06/04/91	VOC
SW039	06/04/91	WQP
SW039	07/08/91	Metal
SW039	07/08/91	Radionuclide
SW039	07/08/91	VOC
SW039	07/08/91	WQP
SW039	08/05/91	Metal
SW039	08/05/91	VOC
SW039	08/05/91	WQP
SW039	09/05/91	Metal
SW039	09/05/91	Radionuclide
SW039	09/05/91	VOC
SW039	09/05/91	WQP
SW039	10/02/91	Metal
SW039	10/02/91	Pesticide
SW039	10/02/91	Radionuclide
SW039	10/02/91	SVOC
SW039	10/02/91	VOC
SW039	10/02/91	WQP
SW039	11/18/91	Metal
SW039	11/18/91	Radionuclide
SW039	11/18/91	VOC
SW039	11/18/91	WQP
SW039	04/15/92	Metal
SW039	04/15/92	VOC
SW039	04/15/92	WQP
SW040	07/30/87	VOC
SW040	07/30/87	WQP
SW040	11/04/92	Metal
SW040	11/04/92	Pesticide
SW040	11/04/92	Radionuclide
SW040	11/04/92	SVOC
SW040	11/04/92	VOC
SW040	11/04/92	WQP
SW040	03/24/93	Metal
SW040	03/24/93	Pesticide
SW040	03/24/93	Radionuclide
SW040	03/24/93	SVOC
SW040	03/24/93	VOC
SW040	03/24/93	WQP
SW041	07/29/87	VOC
SW041	07/29/87	WQP
SW041	11/11/87	VOC
SW041	03/01/89	Metal
SW041	03/01/89	Radionuclide
SW041	03/01/89	WQP
SW041	05/26/89	Metal
SW041	06/04/91	Metal
SW041	06/04/91	Radionuclide
SW041	07/08/91	Metal
SW041	07/08/91	Radionuclide
SW041	08/05/91	Metal
SW041	08/05/91	Radionuclide
SW041	09/05/91	Metal
SW041	10/02/91	Metal
SW041	12/17/92	Metal
SW041	03/24/93	Metal
SW041	03/24/93	Radionuclide
SW032	07/16/90	Radionuclide
SW032	07/16/90	VOC
SW032	07/16/90	WQP
SW032	08/09/90	Metal
SW032	08/09/90	Radionuclide
SW032	08/09/90	VOC
SW032	08/09/90	WQP
SW032	09/13/90	Metal
SW032	09/13/90	Radionuclide
SW032	09/13/90	WQP
SW032	10/04/90	Metal
SW032	10/04/90	Radionuclide
SW032	10/04/90	SVOC
SW032	10/04/90	VOC
SW032	10/04/90	WQP
SW032	11/07/90	Metal
SW032	11/07/90	Radionuclide
SW032	11/07/90	VOC
SW032	11/07/90	WQP
SW032	12/04/90	Metal
SW032	12/04/90	Radionuclide
SW032	12/04/90	VOC
SW032	12/04/90	WQP
SW032	03/13/91	Metal
SW032	03/13/91	Radionuclide
SW032	03/13/91	VOC
SW032	03/13/91	WQP
SW032	04/04/91	Metal
SW032	04/04/91	Pesticide
SW032	04/04/91	Radionuclide
SW032	04/04/91	SVOC
SW032	04/04/91	VOC
SW032	04/04/91	WQP
SW032	05/09/91	Metal
SW032	05/09/91	Radionuclide
SW032	05/09/91	VOC
SW032	05/09/91	WQP
SW032	06/13/91	Metal
SW032	06/13/91	Radionuclide
SW032	06/13/91	VOC
SW032	06/13/91	WQP
SW032	07/10/91	Metal
SW032	07/10/91	Radionuclide
SW032	07/10/91	VOC
SW032	07/10/91	WQP
SW032	08/07/91	Metal
SW032	08/07/91	Radionuclide
SW032	08/07/91	VOC
SW032	08/07/91	WQP
SW032	09/26/91	Metal
SW032	09/26/91	Radionuclide
SW032	09/26/91	VOC
SW032	09/26/91	WQP
SW032	10/10/91	Metal
SW032	10/10/91	Pesticide
SW032	10/10/91	Radionuclide
SW032	10/10/91	SVOC
SW032	10/10/91	VOC
SW032	10/10/91	WQP
SW032	11/13/91	Metal
SW032	11/13/91	Radionuclide
SW032	11/13/91	VOC
SW032	11/13/91	WQP
SW032	01/15/92	Metal
SW032	01/15/92	Radionuclide
SW032	01/15/92	VOC
SW032	01/15/92	WQP
SW032	04/02/92	Metal
SW032	04/02/92	VOC
SW032	04/02/92	WQP
SW033	04/04/91	Radionuclide
SW033	05/13/91	Metal
SW033	05/13/91	Radionuclide
SW033	06/13/91	Metal
SW033	06/13/91	Radionuclide
SW033	07/10/91	Metal
SW033	07/10/91	Radionuclide
SW033	08/07/91	Metal
SW033	08/07/91	Radionuclide
SW033	09/26/91	Metal
SW033	10/10/91	Metal
SW033	11/13/91	Metal
SW033	01/15/92	Metal
SW033	01/15/92	Radionuclide
SW033	04/06/92	Metal
SW033	11/04/92	Metal
SW033	11/04/92	Radionuclide
SW033	03/24/93	Metal
SW033	03/24/93	Radionuclide
SW10295	07/03/95	Metal
SW50193	03/24/93	Metal
SW50193	03/24/93	Radionuclide
SW50293	03/24/93	Metal
SW50293	03/24/93	Radionuclide
SW036	11/20/1990	WQP
SW036	3/15/1991	Metal
SW036	3/15/1991	Radionuclide
SW036	3/15/1991	VOC
SW036	3/15/1991	WQP
SW036	4/8/1991	Metal
SW036	4/8/1991	Pesticide
SW036	4/8/1991	Radionuclide
SW036	4/8/1991	SVOC
SW036	4/8/1991	VOC
SW036	4/8/1991	WQP
SW036	5/16/1991	Metal
SW036	5/16/1991	Radionuclide
SW036	5/16/1991	WQP
SW036	8/13/1991	Metal
SW036	8/13/1991	Radionuclide
SW036	8/13/1991	VOC
SW036	8/13/1991	WQP
SW036	11/7/1991	Metal
SW036	11/7/1991	Radionuclide
SW036	11/7/1991	VOC
SW036	11/7/1991	WQP
SW036	4/8/1992	Metal
SW036	4/8/1992	VOC
SW036	4/8/1992	WQP
SW036	8/25/1992	Metal
SW036	8/25/1992	VOC
SW036	8/25/1992	WQP
SW036	4/18/1994	Metal
SW036	4/18/1994	Pesticide
SW036	4/18/1994	Radionuclide
SW036	4/18/1994	SVOC
SW036	4/18/1994	VOC
SW036	4/18/1994	WQP
SW036	3/23/1995	Metal
SW036	3/23/1995	Pesticide
SW036	3/23/1995	Radionuclide
SW036	3/23/1995	SVOC
SW036	3/23/1995	VOC
SW036	3/23/1995	WQP
SW036	6/1/1995	Metal
SW036	6/1/1995	Pesticide
SW036	6/1/1995	Radionuclide
SW036	6/1/1995	SVOC
SW036	6/1/1995	VOC
SW036	6/1/1995	WQP
SW036	3/17/2003	Metal
SW036	3/17/2003	Radionuclide
SW036	3/22/2003	Metal
SW036	3/22/2003	Radionuclide
SW036	3/25/2003	Metal
SW036	3/25/2003	Radionuclide
SW036	3/27/2003	Metal
SW036	3/27/2003	Radionuclide
SW036	4/1/2003	Metal
SW036	4/1/2003	Radionuclide
SW036	4/3/2003	Metal
SW036	4/3/2003	Radionuclide
SW036	4/7/2003	Metal
SW036	4/7/2003	Radionuclide
SW036	4/14/2003	Metal
SW036	4/14/2003	Radionuclide
SW036	4/19/2003	Metal
SW036	4/19/2003	Radionuclide
SW036	4/22/2003	Metal
SW036	4/22/2003	Radionuclide
SW036	4/28/2003	Metal
SW036	4/28/2003	Radionuclide
SW036	5/10/2003	Metal
SW036	5/10/2003	Radionuclide
SW129	7/22/1991	Metal
SW129	7/22/1991	Radionuclide
SW129	8/13/1991	Metal
SW129	8/13/1991	Radionuclide
SW129	9/18/1991	Metal
SW129	10/23/1991	Metal
SW500	10/5/1992	Metal
SW500	10/5/1992	Radionuclide

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Table 3
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SW041	05/26/89	Radionuclide
SW041	05/26/89	WQP
SW041	06/16/89	Metal
SW041	06/16/89	Radionuclide
SW041	06/16/89	WQP
SW041	11/20/89	Metal
SW041	11/20/89	Radionuclide
SW041	11/20/89	WQP
SW041	12/05/89	Metal
SW041	12/05/89	Radionuclide
SW041	12/05/89	WQP
SW041	01/04/90	Metal
SW041	01/04/90	Radionuclide
SW041	01/04/90	WQP
SW041	02/06/90	Metal
SW041	02/06/90	Radionuclide
SW041	02/06/90	WQP
SW041	03/21/90	Metal
SW041	03/21/90	Radionuclide
SW041	03/21/90	WQP
SW041	04/05/90	
SW041	04/05/90	Metal
SW041	04/05/90	Pesticide
SW041	04/05/90	SVOC
SW041	04/05/90	VOC
SW041	04/05/90	WQP
SW041	05/02/90	Metal
SW041	05/02/90	Radionuclide
SW041	05/02/90	VOC
SW041	05/02/90	WQP
SW041	06/04/90	Metal
SW041	06/04/90	Radionuclide
SW041	06/04/90	VOC
SW041	06/04/90	WQP
SW041	07/05/90	Metal
SW041	07/05/90	Radionuclide
SW041	07/05/90	VOC
SW041	07/05/90	WQP
SW041	08/06/90	Metal
SW041	08/06/90	Radionuclide
SW041	08/06/90	VOC
SW041	08/06/90	WQP
SW041	09/05/90	Metal
SW041	09/05/90	Radionuclide
SW041	09/05/90	VOC
SW041	09/05/90	WQP
SW041	10/02/90	Metal
SW041	10/02/90	Pesticide
SW041	10/02/90	SVOC
SW041	10/02/90	VOC
SW041	10/02/90	WQP
SW041	12/04/90	Metal
SW041	12/04/90	Radionuclide
SW041	12/04/90	VOC
SW041	12/04/90	WQP
SW041	05/03/91	Metal
SW041	05/03/91	Radionuclide
SW041	05/03/91	VOC
SW041	05/03/91	WQP
SW041	06/04/91	Metal
SW041	06/04/91	Radionuclide
SW041	06/04/91	VOC
SW041	06/04/91	WQP
SW041	07/08/91	Metal
SW041	07/08/91	Radionuclide
SW041	07/08/91	VOC
SW041	07/08/91	WQP
SW041	08/05/91	Metal
SW041	08/05/91	Radionuclide
SW041	08/05/91	VOC

SW033	07/01/88	Metal
SW033	07/01/88	Radionuclide
SW033	07/01/88	VOC
SW033	07/01/88	WQP
SW033	04/04/89	Metal
SW033	04/04/89	Pesticide
SW033	04/04/89	Radionuclide
SW033	04/04/89	SVOC
SW033	04/04/89	VOC
SW033	04/04/89	WQP
SW033	05/24/89	Pesticide
SW033	05/24/89	Radionuclide
SW033	05/24/89	WQP
SW033	06/21/89	Metal
SW033	06/21/89	Radionuclide
SW033	06/21/89	VOC
SW033	06/21/89	WQP
SW033	09/19/89	Metal
SW033	09/19/89	Radionuclide
SW033	09/19/89	VOC
SW033	09/19/89	WQP
SW033	10/13/89	Metal
SW033	10/13/89	Pesticide
SW033	10/13/89	Radionuclide
SW033	10/13/89	SVOC
SW033	10/13/89	VOC
SW033	12/15/89	Metal
SW033	12/15/89	Radionuclide
SW033	12/15/89	VOC
SW033	12/15/89	WQP
SW033	01/16/90	Metal
SW033	01/16/90	Radionuclide
SW033	01/16/90	VOC
SW033	01/16/90	WQP
SW033	02/20/90	Radionuclide
SW033	02/20/90	VOC
SW033	03/23/90	Metal
SW033	03/23/90	Radionuclide
SW033	03/23/90	VOC
SW033	04/11/90	
SW033	04/11/90	Metal
SW033	04/11/90	Pesticide
SW033	04/11/90	Radionuclide
SW033	04/11/90	SVOC
SW033	04/11/90	VOC
SW033	04/11/90	WQP
SW033	05/10/90	Metal
SW033	05/10/90	Radionuclide
SW033	05/10/90	VOC
SW033	05/10/90	WQP
SW033	06/07/90	Metal
SW033	06/07/90	Radionuclide
SW033	06/07/90	VOC
SW033	06/07/90	WQP
SW033	07/16/90	Radionuclide
SW033	07/16/90	VOC
SW033	07/16/90	WQP
SW033	08/14/90	Radionuclide
SW033	09/13/90	Metal
SW033	09/13/90	Radionuclide
SW033	09/13/90	WQP
SW033	10/04/90	Metal
SW033	10/04/90	Radionuclide
SW033	10/04/90	SVOC
SW033	10/04/90	VOC
SW033	10/04/90	WQP
SW033	11/07/90	Metal
SW033	11/07/90	Radionuclide
SW033	11/07/90	VOC
SW033	11/07/90	WQP

SW036	5/20/2003	Metal
SW036	5/20/2003	Radionuclide
SW036	7/18/2003	Metal
SW036	7/18/2003	Radionuclide
SW036	4/26/2004	Metal
SW036	4/26/2004	Radionuclide
SW036	5/12/2004	Metal
SW036	5/12/2004	Radionuclide
SW036	6/17/2004	Metal
SW036	6/17/2004	Radionuclide
SW038	10/15/1990	Metal
SW038	10/15/1990	Pesticide
SW038	10/15/1990	Radionuclide
SW038	10/15/1990	SVOC
SW038	10/15/1990	VOC
SW038	10/15/1990	WQP
SW038	11/5/1990	Metal
SW038	11/5/1990	Radionuclide
SW038	11/5/1990	VOC
SW038	11/5/1990	WQP
SW038	12/11/1990	Metal
SW038	12/11/1990	Radionuclide
SW038	12/11/1990	VOC
SW038	12/11/1990	WQP
SW038	3/28/1991	Metal
SW038	3/28/1991	Radionuclide
SW038	3/28/1991	VOC
SW038	3/28/1991	WQP
SW038	4/9/1991	Metal
SW038	4/9/1991	Pesticide
SW038	4/9/1991	Radionuclide
SW038	4/9/1991	SVOC
SW038	4/9/1991	VOC
SW038	4/9/1991	WQP
SW038	5/16/1991	Metal
SW038	5/16/1991	Radionuclide
SW038	5/16/1991	VOC
SW038	5/16/1991	WQP
SW038	6/20/1991	Metal
SW038	6/20/1991	Radionuclide
SW038	6/20/1991	VOC
SW038	6/20/1991	WQP
SW038	7/25/1991	Metal
SW038	7/25/1991	Radionuclide
SW038	7/25/1991	VOC
SW038	7/25/1991	WQP
SW038	8/28/1991	Metal
SW038	8/28/1991	Radionuclide
SW038	8/28/1991	VOC
SW038	8/28/1991	WQP
SW038	9/18/1991	Metal
SW038	9/18/1991	Radionuclide
SW038	9/18/1991	VOC
SW038	9/18/1991	WQP
SW038	10/23/1991	Metal
SW038	10/23/1991	Pesticide
SW038	10/23/1991	Radionuclide
SW038	10/23/1991	SVOC
SW038	10/23/1991	VOC
SW038	10/23/1991	WQP
SW038	11/7/1991	Metal
SW038	11/7/1991	Radionuclide
SW038	11/7/1991	VOC
SW038	11/7/1991	WQP
SW038	1/20/1992	Metal
SW038	1/20/1992	Radionuclide
SW038	1/20/1992	VOC
SW038	1/20/1992	WQP
SW038	4/7/1992	Metal
SW038	4/7/1992	VOC

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Table 3
Sampling and Analytical Summary for OLF Surface Water

SW041	08/05/91	WQP
SW041	09/05/91	Metal
SW041	09/05/91	Radionuclide
SW041	09/05/91	VOC
SW041	09/05/91	WQP
SW041	10/02/91	Metal
SW041	10/02/91	Pesticide
SW041	10/02/91	Radionuclide
SW041	10/02/91	SVOC
SW041	10/02/91	VOC
SW041	10/02/91	WQP
SW041	12/17/92	Metal
SW041	12/17/92	Radionuclide
SW041	12/17/92	VOC
SW041	12/17/92	WQP
SW041	03/24/93	Metal
SW041	03/24/93	Pesticide
SW041	03/24/93	Radionuclide
SW041	03/24/93	SVOC
SW041	03/24/93	VOC
SW041	03/24/93	WQP

SW033	12/04/90	Metal
SW033	12/04/90	Radionuclide
SW033	12/04/90	VOC
SW033	12/04/90	WQP
SW033	03/08/91	Metal
SW033	03/08/91	Radionuclide
SW033	03/08/91	VOC
SW033	03/08/91	WQP
SW033	04/04/91	Metal
SW033	04/04/91	Pesticide
SW033	04/04/91	Radionuclide
SW033	04/04/91	SVOC
SW033	04/04/91	VOC
SW033	04/04/91	WQP
SW033	05/13/91	Metal
SW033	05/13/91	Radionuclide
SW033	05/13/91	VOC
SW033	05/13/91	WQP
SW033	06/13/91	Metal
SW033	06/13/91	Radionuclide
SW033	06/13/91	VOC
SW033	06/13/91	WQP
SW033	07/10/91	Metal
SW033	07/10/91	Radionuclide
SW033	07/10/91	VOC
SW033	07/10/91	WQP
SW033	08/07/91	Metal
SW033	08/07/91	Radionuclide
SW033	08/07/91	VOC
SW033	08/07/91	WQP
SW033	09/26/91	Metal
SW033	09/26/91	Radionuclide
SW033	09/26/91	VOC
SW033	09/26/91	WQP
SW033	10/10/91	Metal
SW033	10/10/91	Pesticide
SW033	10/10/91	Radionuclide
SW033	10/10/91	SVOC
SW033	10/10/91	VOC
SW033	10/10/91	WQP
SW033	11/13/91	Metal
SW033	11/13/91	Radionuclide
SW033	11/13/91	VOC
SW033	11/13/91	WQP
SW033	01/15/92	Metal
SW033	01/15/92	Radionuclide
SW033	01/15/92	VOC
SW033	01/15/92	WQP
SW033	04/06/92	Metal
SW033	04/06/92	VOC
SW033	04/06/92	WQP
SW033	11/04/92	Metal
SW033	11/04/92	Pesticide
SW033	11/04/92	Radionuclide
SW033	11/04/92	SVOC
SW033	11/04/92	VOC
SW033	11/04/92	WQP
SW033	03/24/93	Metal
SW033	03/24/93	Pesticide
SW033	03/24/93	Radionuclide
SW033	03/24/93	SVOC
SW033	03/24/93	VOC
SW033	03/24/93	WQP
SW10295	07/03/95	Metal
SW10295	07/03/95	VOC
SW10295	07/03/95	WQP
SW50193	03/24/93	Metal
SW50193	03/24/93	Pesticide
SW50193	03/24/93	Radionuclide
SW50193	03/24/93	SVOC

SW038	4/7/1992	WQP
SW038	8/10/1992	Metal
SW038	8/10/1992	Radionuclide
SW038	8/10/1992	VOC
SW038	8/10/1992	WQP
SW038	4/18/1994	Metal
SW038	4/18/1994	Pesticide
SW038	4/18/1994	Radionuclide
SW038	4/18/1994	SVOC
SW038	4/18/1994	VOC
SW038	4/18/1994	WQP
SW038	9/30/1994	Metal
SW038	9/30/1994	Pesticide
SW038	9/30/1994	Radionuclide
SW038	9/30/1994	SVOC
SW038	9/30/1994	VOC
SW038	9/30/1994	WQP
SW038	12/13/1994	Metal
SW038	12/13/1994	Pesticide
SW038	12/13/1994	Radionuclide
SW038	12/13/1994	SVOC
SW038	12/13/1994	VOC
SW038	12/13/1994	WQP
SW038	3/23/1995	Metal
SW038	3/23/1995	Pesticide
SW038	3/23/1995	Radionuclide
SW038	3/23/1995	SVOC
SW038	3/23/1995	VOC
SW038	3/23/1995	WQP
SW038	6/1/1995	Metal
SW038	6/1/1995	Pesticide
SW038	6/1/1995	Radionuclide
SW038	6/1/1995	SVOC
SW038	6/1/1995	VOC
SW038	6/1/1995	WQP
SW038	9/26/1995	Metal
SW038	9/26/1995	Pesticide
SW038	9/26/1995	Radionuclide
SW038	9/26/1995	SVOC
SW038	9/26/1995	VOC
SW038	9/26/1995	WQP
SW038	6/8/2004	Metal
SW038	6/8/2004	Radionuclide
SW038	6/8/2004	SVOC
SW038	6/8/2004	VOC
SW129	10/15/1990	Metal
SW129	10/15/1990	Pesticide
SW129	10/15/1990	Radionuclide
SW129	10/15/1990	SVOC
SW129	10/15/1990	VOC
SW129	10/15/1990	WQP
SW129	11/5/1990	Metal
SW129	11/5/1990	Radionuclide
SW129	11/5/1990	VOC
SW129	11/5/1990	WQP
SW129	12/6/1990	Metal
SW129	12/6/1990	Radionuclide
SW129	12/6/1990	VOC
SW129	12/6/1990	WQP
SW129	3/28/1991	Metal
SW129	3/28/1991	Radionuclide
SW129	3/28/1991	VOC
SW129	3/28/1991	WQP
SW129	4/9/1991	Metal
SW129	4/9/1991	Pesticide
SW129	4/9/1991	Radionuclide
SW129	4/9/1991	SVOC
SW129	4/9/1991	VOC
SW129	4/9/1991	WQP
SW129	5/16/1991	Metal

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Table 3
Sampling and Analytical Summary for OLF Surface Water

SW50193	03/24/93	VOC
SW50193	03/24/93	WQP
SW50293	03/24/93	Metal
SW50293	03/24/93	Pesticide
SW50293	03/24/93	Radionuclide
SW50293	03/24/93	SVOC
SW50293	03/24/93	VOC
SW50293	03/24/93	WQP

SW129	5/16/1991	Radionuclide
SW129	5/16/1991	VOC
SW129	5/16/1991	WQP
SW129	6/26/1991	Metal
SW129	6/26/1991	Radionuclide
SW129	6/26/1991	VOC
SW129	6/26/1991	WQP
SW129	7/22/1991	Metal
SW129	7/22/1991	Radionuclide
SW129	7/22/1991	VOC
SW129	7/22/1991	WQP
SW129	8/13/1991	Metal
SW129	8/13/1991	Radionuclide
SW129	8/13/1991	VOC
SW129	8/13/1991	WQP
SW129	9/18/1991	Metal
SW129	9/18/1991	Radionuclide
SW129	9/18/1991	VOC
SW129	9/18/1991	WQP
SW129	10/23/1991	Metal
SW129	10/23/1991	Pesticide
SW129	10/23/1991	Radionuclide
SW129	10/23/1991	SVOC
SW129	10/23/1991	VOC
SW129	10/23/1991	WQP
SW500	10/5/1992	Metal
SW500	10/5/1992	Pesticide
SW500	10/5/1992	Radionuclide
SW500	10/5/1992	SVOC
SW500	10/5/1992	VOC
SW500	10/5/1992	WQP

Table 4
Sampling and Analytical Summary for OLF Sediment

Sediment		
Location Code	Collection Date	Analyte Group
INT. DITCH	4/3/1992	VOC
SED41400	10/4/2000	Radionuclide
SED51693	7/8/1993	Metal
SED51693	7/8/1993	PCB
SED51693	7/8/1993	Pesticide
SED51693	7/8/1993	Radionuclide
SED51693	7/8/1993	SVOC
SED51693	7/8/1993	VOC
SW036	11/29/1993	Metal
SW036	11/29/1993	PCB
SW036	11/29/1993	Pesticide
SW036	11/29/1993	Radionuclide
SW036	11/29/1993	SVOC
SW036	11/29/1993	VOC
SW506	11/5/1992	Metal
SW506	11/5/1992	Radionuclide
SW507	11/5/1992	Metal
SW507	11/5/1992	Radionuclide

Appendix C

Summary – Removal of Radiologically Contaminated Surface Soil

Summary
Removal of Radiologically Contaminated Surface Soil
Original Landfill

Rocky Flats Environmental Technology Site
Rev. 1 - October 29, 2004

OVERVIEW

This work involved the removal of surface soil with uranium contamination above the Wildlife Worker Action Levels at four locations within the Original Landfill (see attached figure for locations). Discussion of source and location of the contamination can be found in the Original Landfill IM/IRA section 2.2. Characterization sampling efforts used to define the hot spots are discussed in sections 4.2 and 4.3 of the Original Landfill IM/IRA. The soil excavation was performed in late July 2004.

SCOPE

Preparation

- Straw bales were placed along the up-gradient and down-gradient sides of the planned excavation.
- Empty waste containers were brought into proximity of the planned excavation and placed on plastic sheets.

Remediation

- A sampling program had previously identified four locations of contaminated surface soil. Each location was staked using GPS surveying techniques. A square was drawn on the surface of the soil, with each side of the square extending out 5 feet north, south, east and west from the stake, creating a 10 feet by 10 feet square.
- Soil was then removed to a depth of at least 6-inches with a track-mounted excavator. Equipment was kept out of the excavation to prevent the spread of contamination. A visual inspection was performed to ensure that the entire square had been removed to the required depth. A radiological survey of the excavator was performed following excavation to assure that no contact had been made with contaminated soil.
- Air monitoring was performed throughout the excavation activities by Radiological Operations for worker safety and to ensure no airborne spread of contamination. No readings approaching the suspension limit of 0.3 DAC in RWP 04-RISS-0031 were noted.
- All the removed soil was placed directly into IP-1 waste containers. Each location required two containers for a total of 8 containers generated by the project. Plastic sheets and accumulated soil were emptied and placed into the waste containers. All 8 waste containers are awaiting shipment for disposal at Envirocare in Utah as low-level waste.

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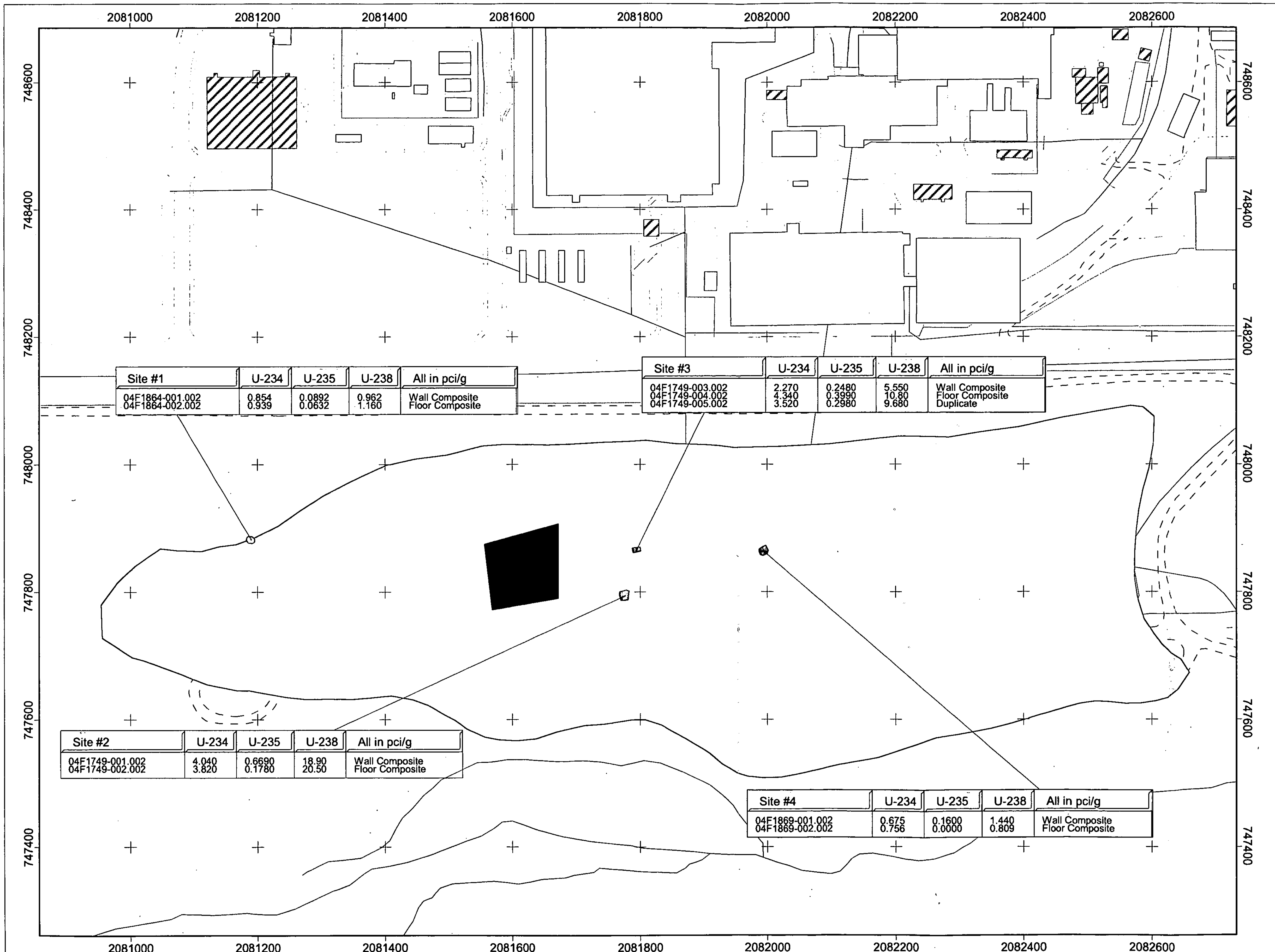
Post-Remediation Sampling

- Two composite samples were collected from within 2 inches of the surface following the excavation of each square.
- One composite sample consisted of soil collected from the middle of each of the four sidewalls of the excavation.
- The other composite sample collected following excavation consisted of soil collected from the surface in the northeast, northwest, southeast and southwest quadrants of the floor, and from the center of the floor.
- Both samples were screened with gamma spectrometry and then sent to an off-site lab for alpha spectrometry confirmation analysis.
- Analytical results from all samples were below action levels for all radionuclides.
- All sample locations were flagged and GPS surveyed. The extent of the excavation was also GPS surveyed.

Erosion Control

- Following receipt of the analyses from the field screen of the samples, permanent erosion controls were performed.
- The edges of each of the four excavations were graded to blend into the surrounding grade.
- Additional straw bales were added to completely surround each of the four excavations.
- Erosion (coconut) mat was placed over the exposed soil of the excavations and over soil disturbed by the movement of the equipment.



Site #1	U-234	U-235	U-238	All in pci/g
04F1864-001.002	0.854	0.0892	0.962	Wall Composite
04F1864-002.002	0.939	0.0632	1.160	Floor Composite

Site #2	U-234	U-235	U-238	All in pci/g
04F1749-001.002	4.040	0.6690	18.90	Wall Composite
04F1749-002.002	3.820	0.1780	20.50	Floor Composite

Site #3	U-234	U-235	U-238	All in pci/g
04F1749-003.002	2.270	0.2480	5.550	Wall Composite
04F1749-004.002	4.340	0.3990	10.80	Floor Composite
04F1749-005.002	3.520	0.2980	9.680	Duplicate

Site #4	U-234	U-235	U-238	All in pci/g
04F1869-001.002	0.675	0.1600	1.440	Wall Composite
04F1869-002.002	0.756	0.0000	0.809	Floor Composite

IHSS Group SW-2 Hot Spot Confirmation Sample Results post Remedial Action

KEY

Surface soil excavation and sampling location

IHSS SW-196

IHSS SW-115

Building

Demolished

Standing

Streams

Paved area

Dirt road

WRW Action Levels:
U-234: 300 pCi/g
U-235: 8 pCi/g
U-238: 351 pCi/g

DRAFT

N

150 0 150

Scale in Feet
1" = 150'
Scale = 1:1800

State Plane Coordinate Projection
Colorado Central Zone
Datum: NAD 27

U.S. Department of Energy
Rocky Flats Environmental Site

Prepared by:

RADMS

Prepared for:

Date: June 2004

KAISER◆HILL COMPANY

W:/Project/Fy2004/SW-2/remediation/posthotspotremediation10-19.apr

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Analytical Results

The following are the analytical results from before and after remediation at each of the four hot spots:

Original Landfill Hotspots Sites	Alpha Spec		All in pCi/g				
	Analytical Results Following Remediation				Analytical Results Prior to Remediation		
	U-234	U-235	U-238		U-234	U-235	U-238
Site 1							
04F1864-001.002	0.854	0.0892	0.962	Wall Composite		46	2000
04F1864-002.002	0.939	0.0632	1.16	Floor Composite			
Site 2							
04F1749-001.002	4.04	0.669	18.9	Wall Composite		19	780
04F1749-002.002	3.82	0.178	20.5	Floor Composite			
Site 3							
04F1749-003.002	2.27	0.248	5.55	Wall Composite		23	1000
04F1749-004.002	4.34	0.399	10.8	Floor Composite			
04F1749-005.002	*3.52*	*0.298*	*9.68*	*Duplicate*			
Site 4							
04F1869-001.002	0.675	0.16	1.44	Wall Composite	2800	670	38000
04F1869-002.002	0.756	0	0.809	Floor Composite			
Wrw_al	**300**	**8**	**351**		**300**	**8**	**351**

(Wildlife Refuge Worker Action Level)

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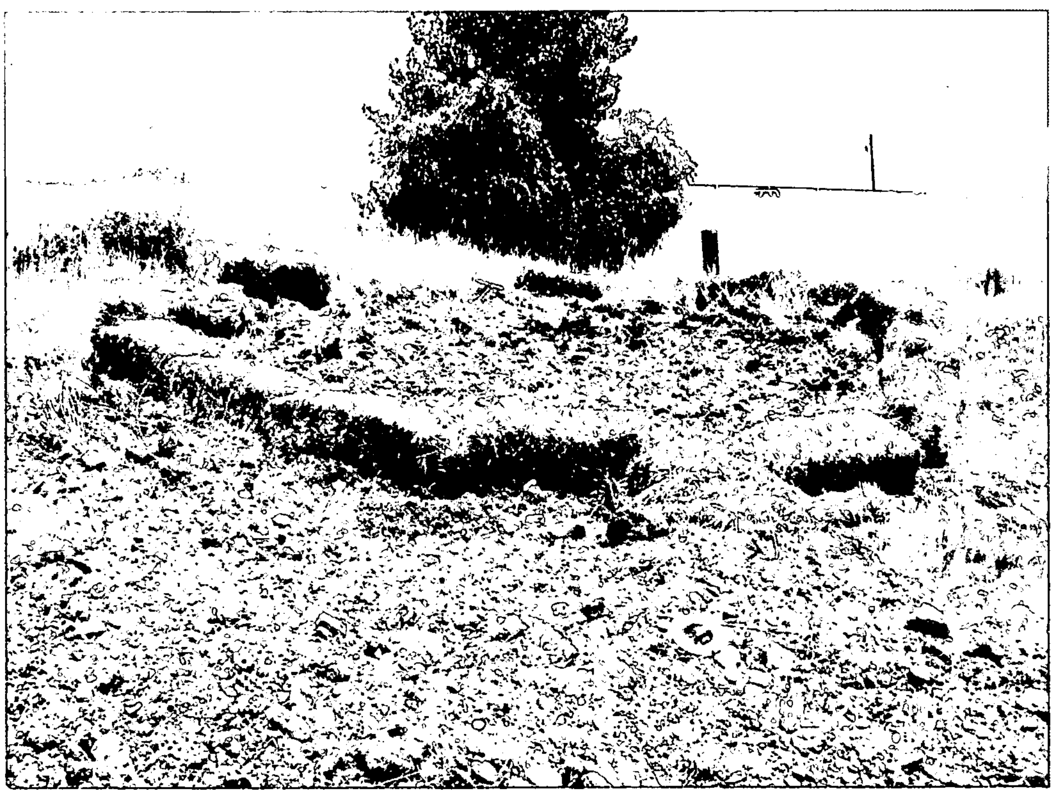
Surveying within Site 1 of the Original Landfill following excavation.

Original Landfill Site 4 following excavation



Appendix D

Accelerated Action Alternatives Cost Estimates

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Original Landfill Accelerated Action Construction Cost Estimate
Alternative 1 - No Action

Rocky Flats Environmental Technology Site

Construction Item	Quantity	Units	Unit Price	Cost	Assumptions/Comments
Mobilization/Demobilization	1	LS	$1,000	$1,000	
Sign Fabrication	22	signs	$500	$11,000	includes signs and posts
Sign Installation	22	signs	$1,000	$22,000	
Vegetation/Erosion Control	5	ac	$2,500	$12,500	Existing Roadway Vegetation
Subtotal				$46,500	
Contingency	15	percent		$6,975	
Construction Project Total (1)				$53,475	with 30% contingency total = $60,450

(1) Construction Project Total does not include construction oversight, QA/QC oversight and testing, preparation of work control documents, design, closure certification document or K-H direct costs.

Operations and Maintenance Costs - Annual Costs

Item	Quantity	Units	Unit Rate	Cost	Assumptions/Comments
Weed control	0.00	acres	$150	$0	$150 per acre/year for weed control
Veg. maintenance/ reseeding	0.00	acres	$30	$0	$30 per acre/year for reseeding
Vegetation monitoring - Fieldwork	0	days	$600	$0	1 ecologists x 1 day x 8 hours/day @$75/hour
Vegetation monitoring - Office	0	days	$600	$0	1 ecologists x 1 day x 8 hours/day @$75/hour
Slope Stability Monitoring - Fieldwork	2	days	$800	$1,600	1 engineer x 1 day x 8 hours/day @$100/hour
Slope Stability Momitoring - Office	4	days	$800	$3,200	1 engineer x 1 day x 8 hours/day @$100/hour
Moitoring Well Sampling - Fieldwork	2	days	$1,200	$2,400	1 team x 1 day x 8 hours/day @$150/hour
Monitoring Well Sampling - Office	4	days	$800	$3,200	1 engineer x 1 day x 8 hours/day @$100/hour
Monitoring Well Sampling - Lab	8	samples	$600	$4,800	
Monitoring Well Maintenance	1	LS	$500	$500	
Surface Water Sampling - Fieldwork	2		$1,200	$2,400	1 team x 1 day x 8 hours/day @$150/hour
Surface Water Sampling - Office	4		$800	$3,200	1 engineer x 1 day x 8 hours/day @$100/hour
Surface Water Sampling - Lab	6	samples	$600	$3,600	
Surface Water Station Maintenance	1	LS	$500	$500	

Total Operations and Maintenance Costs (per year) $ 25,400

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Original Landfill Accelerated Action Construction Cost Estimate
Alternative 2 - Grading with Soil Cover
Rocky Flats Environmental Technology Site

Construction Item	Quantity	Units	Unit Price	Cost	Assumptions/Comments
Mobilization/Demobilization	1	LS	$200,000	$200,000	
Site Preparation (Clear & Grub)	25	acres	$4,000	$100,000	Removal of vegetation & debris
Pregrade Cut	55,000	cy	$6	$330,000	Cut to reach subgrade elevations/slopes
Pregrade Fill	105,000	cy	$14	$1,470,000	Fill to reach subgrade elevations/slopes
Final Grade Preparation	25	acres	$3,000	$75,000	Fine Grading
Soil Cover	65000	cy	$14	$910,000	Rocky Flats Alluvium
Vegetation	30	acres	$6,000	$180,000	Native seeding with crimped straw
Surface Drainage Ditches/Diversion	1	LS	$200,000	$200,000	
Vegetation/Erosion Control	30	ac	$2,500	$75,000	
Subtotal				$3,540,000	
Contingency	15	percent		$531,000	
Construction Project Total (1)				$4,071,000	Total cost with 30% contingency = $4,602,000

(1) Construction Project Total does not include construction oversight, QA/QC oversight and testing, preparation of work control documents, design, closure certification document or K-H direct costs.

Operations and Maintenance Costs - Annual Costs

Item	Quantity	Units	Unit Rate	Cost	Assumptions/Comments
Weed control	25.00	acres	$150	$3,750	$150 per acre/year for weed control
Veg. maintenance/ reseeding	5.00	acres	$30	$150	$30 per acre/year for reseeding
Vegetation monitoring - Fieldwork	1	days	$600	$600	1 ecologists x 1 day x 8 hours/day @$75/hour
Vegetation monitoring - Office	2	days	$600	$1,200	1 ecologists x 1 day x 8 hours/day @$75/hour
Slope Stability Monitoring - Fieldwork	2	days	$800	$1,600	1 engineer x 1 day x 8 hours/day @$100/hour
Slope Stability Momitoring - Office	4	days	$800	$3,200	1 engineer x 1 day x 8 hours/day @$100/hour
Moitoring Well Sampling - Fieldwork	2	days	$1,200	$2,400	1 team x 1 day x 8 hours/day @$150/hour
Monitoring Well Sampling - Office	4	days	$800	$3,200	1 engineer x 1 day x 8 hours/day @$100/hour
Monitoring Well Sampling - Lab	8	samples	$600	$4,800	
Monitoring Well Maintenance	1	LS	$500	$500	
Surface Water Sampling - Fieldwork	2		$1,200	$2,400	1 team x 1 day x 8 hours/day @$150/hour
Surface Water Sampling - Office	4		$800	$3,200	1 engineer x 1 day x 8 hours/day @$100/hour
Surface Water Sampling - Lab	6	samples	$600	$3,600	
Surface Water Station Maintenance	1	LS	$500	$500	
Total Operations and Maintenance Costs (per year)				$ 31,100	

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Original Landfill Accelerated Action Construction Cost Estimate
Alternative 3 - Grading with Soil Cover & Buttress Fill

Rocky Flats Environmental Technology Site

Construction Item	Quantity	Units	Unit Price	Cost	Assumptions/Comments
Mobilization/Demobilization	1	LS	$200,000	$200,000	
Site Preparation (Clear & Grub)	30	acres	$4,000	$120,000	Removal of vegetation & debris
Pregrade Cut	55,000	cy	$6	$330,000	Cut to reach subgrade elevations/slopes
Pregrade Fill	105,000		$14	$1,470,000	Fill to reach subgrade elevations/slopes
Final Grade Preparation	30	acres	$3,000	$90,000	Fine Grading
Buttress Fill	60000	cy	$28	$1,680,000	Structural Fill
Soil Cover	65000	cy	$14	$910,000	Rocky Flats Alluvium
Vegetation	30	acres	$6,000	$180,000	Native seeding with crimped straw
Surface Drainage Ditches/Diversion	1	LS	$200,000	$200,000	
Vegetation/Erosion Control	30	ac	$2,500	$75,000	
Subtotal				$5,255,000	
Contingency	15	percent		$788,250	
Construction Project Total (1)				$6,043,250	Total cost with 30% contingency = $6,831,500

(1) Construction Project Total does not include construction oversight, QA/QC oversight and testing, preparation of work control documents, design, closure certification document or K-H direct costs.

Operations and Maintenance Costs - Annual Costs

Item	Quantity	Units	Unit Rate	Cost	Assumptions/Comments
Weed control	25.00	acres	$150	$3,750	$150 per acre/year for weed control
Veg. maintenance/ reseeding	5.00	acres	$30	$150	$30 per acre/year for reseeding
Vegetation monitoring - fieldwork	1	days	$600	$600	1 ecologists x 1 day x 8 hours/day @$75/hour
Vegetation monitoring - office	2	days	$600	$1,200	1 ecologists x 1 day x 8 hours/day @$75/hour
Slope Stability Monitoring - Fieldwork	2	days	$800	$1,600	1 engineer x 1 day x 8 hours/day @$100/hour
Slope Stability Momitoring - Office	4	days	$800	$3,200	1 engineer x 1 day x 8 hours/day @$100/hour
Moitoring Well Sampling - fieldwork	2	days	$1,200	$2,400	1 team x 1 day x 8 hours/day @$150/hour
Monitoring Well Sampling - Office	4	days	$800	$3,200	1 engineer x 1 day x 8 hours/day @$100/hour
Monitoring Well Sampling - Lab	8	samples	$600	$4,800	
Monitoring Well Maintenance	1	LS	$500	$500	
Surface Water Sampling - Fieldwork	2		$1,200	$2,400	1 team x 1 day x 8 hours/day @$150/hour
Surface Water Sampling - Office	4		$800	$3,200	1 engineer x 1 day x 8 hours/day @$100/hour
Surface Water Sampling - Lab	6	samples	$600	$3,600	
Surface Water Station Maintenance	1	LS	$500	$500	

Total Operations and Maintenance Costs (per year) | $ 31,100

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Original Landfill Accelerated Action Construction Cost Estimate
Alternative 4 - Removal with Offiste Disposal (10% mixed waste & 90% solid waste)

Rocky Flats Environmental Technology Site

Construction Item	Quantity	Units	Unit Price	Cost	Assumptions/Comments
Mobilization/Demobilization	1	LS	$300,000	$300,000	
Site Preparation (Clear & Grub)	30	acres	$4,000	$120,000	Removal of vegetation & debris
Excavation	160,000	cy	$8	$1,280,000	Cut & fill to reach subgrade elevations/slopes
Sampling for Disposal Characterization	1,600	samples	$1,000	$1,600,000	1 sample every 100 cy
Disposal (Offsite, Mixed Waste)	19,200	cy	$4,000	$76,800,000	10
Disposal (Offsite, Soild Waste)	172,800	cy	$40	$6,912,000	90
Pregrade Fill	100,000		$8	$800,000	
Final Grade Preparation	30	acres	$3,000	$90,000	Fine Grading
Vegetation	30	acres	$6,000	$180,000	Native seeding with crimped straw
Surface Drainage Ditches/Diversion	1	LS	$200,000	$200,000	
Vegetation/Erosion Control	30	ac	$2,500	$75,000	
Subtotal				$88,357,000	
Contingency	15	percent		$13,253,550	
Construction Project Total (1)				$101,610,550	Total cost with 30% contingency = $114,864,100

(1) Construction Project Total does not include construction oversight, QA/QC oversight and testing, preparation of work control documents, design, closure certification document or K-H direct costs.

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Original Landfill Accelerated Action Construction Cost Estimate
Alternative 4 - Removal with Offiste Disposal (25% mixed waste & 75% solid waste)

Rocky Flats Environmental Technology Site

Construction Item	Quantity	Units	Unit Price	Cost	Assumptions/Comments
Mobilization/Demobilization	1	LS	$300,000	$300,000	
Site Preparation (Clear & Grub)	30	acres	$4,000	$120,000	Removal of vegetation & debris
Excavation	160,000	cy	$8	$1,280,000	Cut & fill to reach subgrade elevations/slopes
Sampling for Disposal Characterization	1,600	samples	$1,000	$1,600,000	1 sample every 100 cy
Disposal (Offsite, Mixed Waste)	48,000	cy	$4,000	$192,000,000	25
Disposal (Offsite, Soild Waste)	144,000	cy	$40	$5,760,000	75
Pregrade Fill	100,000		$8	$800,000	
Final Grade Preparation	30	acres	$3,000	$90,000	Fine Grading
Vegetation	30	acres	$6,000	$180,000	Native seeding with crimped straw
Surface Drainage Ditches/Diversion	1	LS	$200,000	$200,000	
Vegetation/Erosion Control	30	ac	$2,500	$75,000	
Subtotal				$202,405,000	
Contingency	15	percent		$30,360,750	
Construction Project Total (1)				$232,765,750	Total cost with 30% contingency = $263,126,500

(1) Construction Project Total does not include construction oversight, QA/QC oversight and testing, preparation of work control documents, design, closure certification document or K-H direct costs.

Appendix E

Wetland Mitigation Plan

Original Landfill Project Wetland Mitigation Plan For The Rocky Flats Environmental Technology Site

MARCH 2004

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Original Landfill Project Wetland Mitigation Plan

Introduction

The Rocky Flats Environmental Technology Site (the Site) is a U.S. Department of Energy (DOE) facility located in rural northern Jefferson County, Colorado, which is approximately 16 miles northwest of Denver. It is approximately 6,200 acres in size. The developed portion of the site, referred to as the Industrial Area (IA), is centrally located within RFETS and occupies approximately 400 acres. The Rocky Flats Buffer Zone surrounds the IA and occupies the remaining 5,800 acres. The Original Landfill (OLF) is located in the RFETS Buffer Zone (BZ), south of the Industrial Area (IA; Figure 1). The proposed alternative (for which this wetland mitigation plan was prepared) consists of the removal of surface soil "hot spots" (completed in August 2004), clearing and grubbing of the landfill area, area grading, and implementing the presumptive remedy by placement of a soil cover, cover re-vegetation, monitoring, and institutional controls. Remediation activities will require unavoidable impacts to wetlands within the OLF project area. The wetland mitigation plan outlines the approach and basic plan that will be taken to mitigate for wetland impacts.

Project Information

Location of Project/Ownership

The OLF area located south of the IA at T2S,R70W, Sec. 10 and 15 (Figure 1). The OLF occupies approximately 20 acres.

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Historical Background of OLF

For historical information on the OLF see the "*Draft Interim Measure/Interim Remedial Action for the Original Landfill (including IHSS Group SW-2; IHSS 115 and IHSS 196, Filter Backwash Pond*" document (K-H 2004a) of which this wetland mitigation plan is an Appendix.

Environmental Description of OLF Area

Physiography

The Site is located on the western margin of the Colorado Piedmont section of the Great Plains Physiographic Province at an elevation of approximately 6,000 feet (K-H 1996a). The Colorado Piedmont is characterized as an area of dissected and denuded topography, representing an old erosion surface along the eastern margin of the Rocky Mountains. Several pediments (broad sloping planes formed by coalescing alluvial fans along a mountain front) developed across bedrock in the RFETS area during the Quaternary Period (Scott 1963). The Rocky Flats pediment is the most extensive of these pediments.

The IA is located on a relatively flat surface of the Rocky Flats pediment. The pediment surface has been eroded by Walnut Creek on the north and Woman Creek on the south. As a result, the pediment surface is located at an elevation of 50 feet to 150 feet above the creeks. The grade of the gently eastward-sloping surface of the Rocky Flats pediment ranges from one percent in the IA to approximately two percent just east of the IA. Further east, the pediment's nearly flat-lying surface gives way to lower gently rolling terrain of the High Plains section of the Great Plains Physiographic Province (K-H, 1996a).

Four ephemeral creeks drain the surface water from the Site. The surface water that flows from the northern portion of RFETS is drained by Rock Creek, which is a northeast-trending tributary of Coal Creek. The central and southern portions of the site are drained by Walnut Creek, South Walnut Creek, and Woman Creek. These drainages are all tributaries of Big Dry Creek that flows eastward. Coal Creek separates all of the streams on the Rocky Flats pediment from the Front Range foothills. Surface water flow in these creeks is generally ephemeral; however, some reaches may support intermittent or perennial flow.

Climate

The climate at the Site is characterized as semi-arid (K-H, 1996a) with a mean annual precipitation of approximately 15.5 inches, based on 20-year means for Boulder and Lakewood, Colorado. The wettest season is spring (March through May), which accounts for approximately 40 percent of the annual precipitation, much of which is snow. Thunderstorms during the summer months provide another 30 percent of the annual precipitation. The precipitation gradually declines through the summer, fall and winter (K-H, 1996a). Average annual pan evaporation in central Colorado is approximately 55 inches (DBS 2001).
The predominant wind direction at the Site is northwesterly, and average wind speeds are under 15 miles per hour. Daytime heating causes upslope winds to form, with northeasterly winds common over the broad South Platte River Valley. More localized southeasterly winds

also occasionally occur during the day at the Site because the terrain is oriented southeast toward Standley Lake and the City of Arvada. The winds reverse at night with a shallow westerly drainage wind forming over the site and a broad southerly drainage wind forming over the South Platte River Valley (DOE 1999).

The Site is noted for its strong winds. Gusty winds frequently occur with thunderstorms and the passage of weather fronts. The highest wind speeds occur during the winter as westerly windstorms, known as Chinooks. The windstorm season at the site extends from late November into April, with the height of the season usually occurring in January. The windstorms typically last 8 to 16 hours, with wind speeds exceeding 75 miles per hour in almost every season. Wind gusts exceeding 100 miles per hour are experienced every three to four years (DOE 1999).

Geology

Geologic units beneath the OLF consist of unconsolidated Quaternary deposits that lie unconformably over Cretaceous claystone bedrock. The unconsolidated surface deposits include the Rocky Flats Alluvium that dominates the surface at the Site, colluvial materials that form the slopes of the Woman Creek valley, and valley fill materials on the bottom of Woman Creek valley (EG&Ga, 1995; K-H, 1996a). These materials overlie the Laramie Formation bedrock (Metcalf & Eddy 1995). Geologic units in the OLF area are described below.

Rocky Flats Alluvium

The Rocky Flats Alluvium was deposited by a system of coalescing alluvial fans aggraded by debris flows and braided streams along the base of the Front Range at the mouth of Coal Creek Canyon (EG&G 1995a). The alluvial deposits generally consist of beds and lenses of poorly sorted, clast- and matrix-supported, white to pink, sandy cobbly gravel, gravelly sand, and silty sand (K-H, 1996a). The thickness of this unit ranges from about 3 feet to 30 feet in the areas where the pediment deposits overlie Cretaceous-aged bedrock (K-H, 1996a).

Colluvial Deposits

Colluvial deposits along the valley slopes at the Site are middle Pleistocene to Recent in age (K-H, 1996a). The colluvial material commonly consists of dark-gray to light-reddish-brown, silty sand, sandy silt, clayey silt, and silty clay that contains minor amounts of boulders and cobbles. The unit locally includes clast- and matrix-supported boulders and cobbles, and coarse to fine gravel in a silty-clay matrix. These materials are well graded to poorly graded and unstratified to poorly stratified. Clasts are typically subangular to subrounded, and their sedimentological composition reflects that of the bedrock and surface deposits from which they were derived. The thickness of the colluvial deposits ranges from 3 to 15 feet.

In the OLF area the unconsolidated colluvial deposits consist of sandy, clayey gravel (derived from the adjacent Rocky Flats Alluvium) to sandy clay (Metcalf & Eddy 1995). The colluvium is frequently mixed with fill material in the landfill. Soil borings indicate that the

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thickness of the colluvium ranges from 1 to 13 feet. The colluvium is damp to moist, although it can be wet near its contact with the Laramie Formation (Metcalf & Eddy 1995).

Valley-fill Alluvium

Valley-fill alluvium, located along the Woman Creek drainage, includes channel and terrace deposits related to the modern stream. These Recent alluvial deposits are commonly grayish-brown, slightly cobbly, silty sand to sandy, clayey silt in the upper part, and poorly sorted, clast supported, slightly cobbly, gravel in a light yellowish brown, clayey, silty sand matrix in the lower part (K-H, 1996a). Clasts are mostly subangular quartzite, with a minor amount of subrounded sandstone derived from older Quaternary deposits. The thickness of these deposits ranges from approximately 3 to 15 feet, with an average of about 10 feet. During geotechnical investigations at the OLF (Metcalf & Eddy 1995), valley fill alluvium was encountered in three boreholes along the toe of the landfill. The alluvium consisted of medium dense to dense, sandy, silty, clayey gravel with cobbles. The alluvium ranged from 5 to 7 feet thick, and groundwater was encountered as shallow as two feet below ground surface (bgs).

Laramie Formation

Bedrock in the OLF area is Laramie Formation (K-H, 1996a). The Cretaceous-aged Laramie Formation is approximately 600 feet to 800 feet thick. It has been informally divided into upper and lower members (K-H, 1996a). The upper Laramie Formation is generally distinguished from the lower Laramie Formation where the upper Laramie Formation is dominantly composed of fine-grained sedimentary rocks (primarily claystone with no thick sandstone beds). The upper part of the upper Laramie Formation is approximately 300 feet to 500 feet thick, and consists primarily of olive-gray to yellowish orange claystone with large ironstone nodules. A few thin, discontinuous coal seams occur in the upper Laramie Formation. Lenticular beds of platey laminated or friable, calcareous, fine-grained, light olive-gray sandstone occur in the upper Laramie Formation, particularly in the upper portions of the formation.

In the OLF area, the Laramie Formation is a weak claystone formation that underlies the soil-bearing slopes in the area of the OLF (Metcalf & Eddy 1995). It is severely weathered (soft, plastic and moist) in its near-surface aspect and underlies surficial materials in over 50 percent of borings. Moderately weathered Laramie Formation underlies the severely weathered Laramie Formation and is locally plastic, soft, damp, and fractured. It was encountered underlying surficial material in approximately 35 percent of the borings, indicating that the severely eroded Laramie Formation was sometimes displaced through sliding or erosion. Unweathered Laramie is the deepest component of the upper member and is similar to the moderately weathered Laramie Formation, although somewhat drier (Metcalf & Eddy 1995).

Groundwater

The uppermost groundwater is shallow, unconfined groundwater that occurs within the Rocky Flats Alluvium, colluvial deposits, valley fill alluvium, and the weathered Laramie Formation.

This water bearing zone is also referred to as the Uppermost Hydrostratigraphic Unit (UHSU) (EG&G, 1995b). The UHSU is not an "aquifer" because it is not capable of yielding significant and useable quantities of groundwater to wells or springs (EG&G, 1995b). Soil borings in the Rocky Flats alluvium indicate that groundwater appears hydraulically disconnected from the LHSU groundwater. A review of water level change in time reveals that average saturated heights above the weathered bedrock are quite variable. For example, saturated heights range from 0 to 5 feet along Woman Creek; below the bedrock in the east-central waste area; 5 to 10 feet in the central waste area; 0 to 5 feet in the western waste area; and from 10 to more than 40 feet above the bedrock north of the OLF.

UHSU groundwater typically flows towards the nearest stream, or seep area. Flows are strongly affected by unconsolidated material hydraulic properties, and the morphology and orientation of the underlying claystone bedrock and topographic surfaces. Within the OLF waste extent, areas of greater vegetation density typically indicate zones of shallow groundwater or seeps. Groundwater elevations vary seasonally, typically on the order of 5 to 10 feet primarily due to direct precipitation recharge and evapotranspiration. The highest groundwater levels occur in the late winter and spring, and the lowest groundwater levels occur during the late summer and fall. This variability typically causes any seep discharges in the area to be ephemeral.

Surface Water

The OLF is located within the Woman Creek drainage basin, which extends eastward from the base of the foothills near the mouth of Coal Creek Canyon to Standley Lake. The long-term average annual yield generated by this basin is 32.1 acre-feet, with average storms producing surface flows of 4 to 7 cubic feet per second (cfs). During extreme precipitation events (greater than the 15-year return occurrence based on precipitation), surface flows up to 40 cfs have been generated. Although seasonal flows can be low, Woman Creek receives continuous flow from Antelope Springs Creek. The reach of Woman Creek adjacent to the OLF is a gaining reach of stream (groundwater discharges to surface water); however, this inflow is likely due to inflow from the south side of the valley and seepage from the old orchard area (K-H, 1996a).

The Woman Creek drainage basin has an artificial water control structure, the South Interceptor Ditch (SID), which intercepts runoff and routes it to Pond C-2. This runoff would normally flow into Woman Creek or percolate into the underlying subsurface materials of the basin. The Woman Creek diversion dam routes all Woman Creek flows less than the 100-year flood peak around Pond C-2 (K-H, 1996a). With the completion of the Woman Creek Reservoir, located just east of Indiana Street and operated by the city of Westminster, Woman Creek flows are detained in cells of the reservoir until the water quality has been assured by monitoring of Site discharges via Woman Creek Reservoir into the Walnut Creek Drainage below Great Western Reservoir.

In the past, most natural flows in Woman Creek were diverted to Mower Reservoir and did not exit the Site via Woman Creek. This is no longer the case. The Mower Ditch headgates were upgraded, and water in Woman Creek leaves RFETS via Woman Creek (at GS01) and

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enters the Woman Creek Reservoir. In the past, Pond C-2 (located off-channel in the Woman Creek drainage) was sampled and then pumped to the offsite Broomfield Diversion Ditch. Currently, the Site discharges Pond C-2 directly into Woman Creek via pump (at GS31); the water then flows to the Woman Creek Reservoir.

Ecological Setting

Vegetation

The overall OLF work area crosses several plant community and soil types. The pediment top on the north portion of the OLF project area is composed largely of the Rocky Flats Alluvium. The upper part of the OLF work area is located on this surface. The soil types on this surface are classified as Flatirons very cobbly sandy loam and Nederland very cobbly sandy loam (SCS 1980). The vegetation on this surface is predominantly xeric tallgrass prairie on the western portions of the Site and gradually changes to a needle and threadgrass community as the alluvium thins to the east (K-H 1997). Common species on the xeric tallgrass prairie include big bluestem (*Andropogon gerardii*), little bluestem (*Andropogon scoparius*), mountain muhly (*Muhlenbergia montana*), needle and thread grass (*Stipa comata*), blue grama (*Bouteloua gracilis*), side-oats grama (*Bouteloua curtipendula*), sunsedge (*Carex heliophila*), Canada bluegrass (*Poa compressa*), and a variety of other graminoid and forb species (K-H 1997). The dominance of these species varies from location to location.

The hillside area in the OLF area is dominated by mesic mixed and reclaimed grassland communities. Although native soils on the hillslopes at the Site are classified as Denver-Kutch-Midway clay loams (SCS 1980), much of the OLF area has been reworked and disturbed. Common species on mesic mixed grassland portions of the OLF includes blue grama, side-oats grama, western wheatgrass (*Agropyron smithii*), green needle grass (*Stipa viridula*), Kentucky bluegrass (*Poa pratensis*), Canada bluegrass, Japanese brome (*Bromus japonicus*), and other forbs and graminoids (K-H 1997). However, along much of the SID and other disturbed areas of the OLF hillside the vegetation consists of exotic, reclamation grasses such as smooth brome (*Bromus inermis*), intermediate wheatgrass (*Agropyron intermedium*), and other non-native species. The noxious weeds, diffuse knapweed (*Centaurea diffusa*) and Scotch thistle (*Onopordum acanthium*) are also prevalent, along with several others that are less abundant in the area.

Jurisdiction wetlands in the OLF area are shown in Figure 1. Within the OLF area, the South Interceptor Ditch (SID) has also been designated as a jurisdictional wetland. South of the landfill area, wetland areas are associated with springs and riparian fringe in the Woman Creek drainage. The SID wetland is a narrow, linear ditch, with some cattails (*Typha latifolia*) and coyote willow (*Salix exigua*), and as such has lower functional integrity than natural wetlands associated with Woman Creek (COE 1994). On the hillside above the SID, additional wet areas have developed over the years where outflow pipelines from the IA have exited. At some of these locations, enough moisture has been present at or near the ground surface to support the growth of vegetation characteristic of wetter areas. Coyote willow, plains cottonwood trees (*Populus deltoides*), and arctic rush (*Juncus balticus*) are common in some of these areas. Along Woman Creek, the wetlands are dominated by plains cottonwood,

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coyote willow, false indigo (*Amorpha fruticosa*), snowberry (*Symphoricarpos occidentalis*), arctic rush, and various other plants.

Fauna

Wildlife use in the OLF area is comparable to that documented elsewhere on the grasslands and riparian areas at the Site (K-H 2001). Common wildlife species that could be encountered include small mammals such as deer mice (*Peromyscus maniculatus*), prairie voles (*Microtus ochrogaster*), meadow voles (*Microtus pennsylvanicus*), and house mice (*Mus musculus*), which provide forage for predators like raptors and coyotes (*Canis latrans*). Common raptors at the Site include red-tailed hawks (*Buteo jamaicensis*), Swainson's hawks (*Buteo swainsoni*), great horned owls (*Bubo virginianus*), and kestrels (*Falco sparverius*). Herptiles would be represented by boreal chorus frogs (*Pseudacris triseriatus maculata*), leopard frogs (*Rana pipiens*), and prairie rattlesnakes (*Crotalus viridis*). A variety of songbirds could be found utilizing the grassland and riparian habitats at different times of the year. Western meadowlarks (*Sturnella neglecta*) and vesper sparrows (*Pooecetes gramineus*) are common inhabitants of the grasslands, while Bullock's orioles (*Icterus bullockii*), American goldfinches (*Carduelis tristis*), yellow warblers (*Dendroica petechia*), brown-headed cowbirds (*Molothrus ater*), and other songbirds are common along the streams. Mule deer (*Odocoileus hemionus*) and an occasional white-tailed deer (*Odocoileus virginianus*) also utilize the habitat in and around the OLF work area.

Even though the OLF is a highly disturbed site, the area includes portions of the Preble's Meadow Jumping Mouse (Preble's mouse; *Zapus hudsonius preblei*) protection areas at the Site and wetland areas associated with surface water in the area. The Preble's mouse is listed as threatened by the U.S. Fish and Wildlife Service (USFWS). This listing provides special protection for the species under the Endangered Species Act, and potential remedial actions at the OLF must be evaluated for potential impacts to the Preble' mouse. Preble's mice have been identified in all the major drainages of the Site: Rock Creek, Walnut Creek, and Woman Creek, and the Smart Ditch drainages. The plant communities present in these areas provide a suitable habitat for this small mammal. Preble's mice at the Site are restricted to riparian areas and pond margins, apparently requiring multi-strata vegetation with abundant herbaceous cover. Preble's populations at the Site are found in association with the riparian zone and seep wetlands across the Site. The vegetation communities that provide Preble's habitat include the Great Plains riparian woodland complex, tall upland shrubland, wetlands adjacent to these communities, and some of the upland grasslands surrounding these areas. Recent studies have produced a better understanding of population centers of the species at the Site (K-H 1999, 2000, 2001).

Preble's mice have been captured along Woman Creek in the area of the OLF where a significant amount of suitable habitat occurs. The Preble's mice were captured in riparian areas with well-developed shrub canopies and an understory of grasses and forbs. This is typical of habitats occupied by the subspecies throughout its range (K-H 1996b). The current Preble's protection areas at the Site includes a portion of the OLF area below the SID. The Preble's habitat continues east-west along Woman Creek. Section 7 consultations with the

U.S. Fish and Wildlife Service are ongoing to address Preble's mouse impacts resulting from the OLF project (K-H 2004b).

Existing Functions and Values

The function and value of the wetlands within the OLF work area provide several functions including water quality enhancement, filtering or trapping of sediment, nutrients, and toxic compounds, ground water recharge and discharge, minor flood conveyance and attenuation, and providing habitat for many plant and animal species at the Site.

Buffers

The areas surrounding the OLF work area and the wetlands within the work area include undeveloped portions of the Buffer Zone and the developed IA. The IA is located to the north of the OLF project area while the Buffer Zone surrounds the project area on the other three sides.

Project Approach

The OLF is being addressed as an accelerated action under the Rocky Flats Cleanup Agreement (RFCA), a combined CERCLA federal facility agreement and RCRA/CHWA Corrective Action Order. Based upon an evaluation of the OLF operation and the waste types and the risks posed by exposure pathways from the OLF, an accelerated action consistent with municipal and military landfill presumptive remedies of source containment after hot spot removal has been determined to be appropriate for the OLF (K-H 2004a). The proposed action is to implement the presumptive remedy of source containment. There are two pathways of exposure to be addressed by source containment:

- direct exposure to disposed waste and commingled soil; and
- surface erosion and runoff of contaminants into surface water.

The components of the source containment remedy that are necessary to address these pathways are:

- a landfill cover to prevent direct contact with landfill soil or debris;
- the landfill cover must also adequately control erosion caused by water run on and run off; and
- institutional controls to supplement the engineering controls to appropriately monitor and maintain the remedy.

In addition to these components, ground water and surface water monitoring will be done to evaluate whether contamination is potentially migrating from the source area and creating a path of exposure through surface water.

The proposed alternative consists of the removal of surface soil "hot spots" (completed in August 2004), clearing and grubbing of the landfill area, area grading, and implementing the presumptive remedy by placement of a soil cover, cover re-vegetation, monitoring, and institutional controls. The surface soil hot spots would be removed prior to all other activities at the site to enhance worker safety.

Control measures would be implemented during this activity to control the spread and release of contamination. The control measures would include the establishment of work zones, decontamination procedures, dust suppression methods, traction mats, visual inspections, and radiological surveys. Work would be suspended when environmental conditions such as during high winds that greatly increase the possibility of the spread of contaminated materials. Monitoring would be performed, as necessary, to verify that there has been no release of contaminated materials.

Excavated areas would be carefully monitored with appropriate field screening devices and laboratory analyses to determine the outer limits of the contaminated surface soil areas. Field screening using standard Site instrumentation would be used to verification the depth and extent of excavation to below the action levels (e.g., NE Electra, micro-R, Ludlum 12, HPGE). Confirmation soil samples would be taken for final isotopic analysis. Following the confirmation samples, non-impacted soils from locations adjacent to the excavated areas would be moved to reduce surface slopes and to blend excavated areas into the surrounding surfaces prior to the action for the entire OLF.

The waste fill areas would be graded to a constant 18 percent (5.5:1) slope angle using a cut and fill approach that is as balanced as possible. Standard earth-moving equipment, such as dozers, hoes or scrapers, would be used to cut the areas where the slope exceeds the desired 18 percent and to fill the areas where the slope is less than the desired 18 percent slope. It is estimated that approximately 70,000 cubic yards of waste fill material would be moved during the process. Control measures would be implemented during the grading process to control the spread and release of waste materials in the OLF. The control measures would include the establishment of work zones, decontamination procedures, dust suppression methods, traction mats, visual inspections, and radiological surveys. Work would be suspended when environmental conditions could greatly increase the possibility of the spread of contaminated materials. Monitoring would be performed, as necessary, to verify that there has been no release of contaminated materials. Erosion controls will be used to control runoff/sedimentation from the project area.

After the grading of the landfill surface is complete, a soil cover will be placed over the landfill to a minimum thickness of 2 feet. About 65,000 cubic yards of local or onsite soil will be used to construct the cover. The soil cover will be compacted sufficiently to provide a stable cover system to promote surface water runoff, reduce surface water ponding, and increase overall slope stability. Revegetation of the soil cover with native species will slow runoff and allow "greater" infiltration. The seeding will be conducted along with erosion control matting or mulch to prevent erosion of the cover while allowing the vegetation to establish a strong stand.

As a result of the remediation actions on the OLF approximately 1.24 acres of jurisdictional wetlands (COE 1994) will be impacted.

Impacted Wetland Area Descriptions

Based on the 1994 U.S. Corps of Engineers wetland report for the Site (COE 1994), approximately 1.24 acres of jurisdictional wetlands may be disturbed by the remediation and construction activities. Table 1 lists the wetland types and acreages that may be impacted. Figure 1 shows the locations of these areas.

Table 1. Wetland Impacts

Wetland Type	Acreage
Palustrine emergent, seasonally and semipermanently flooded	0.61
Palustrine, scrub-shrub, seasonally flooded	0.63
Total	1.24

The SID wetland locations consist of a linear, man-made ditch with some cattails and coyote willow. The wetland impacts along Woman Creek will occur in palustrine emergent and scrub-shrub wetland areas dominated by cattails, arctic rush, snowberry, coyote willow, and some plains cottonwood trees.

Mitigation Approach

A plan to mitigate wetland impacts has been developed to offset the wetland losses resulting from the OLF project. The typical approach to wetland issues is to 1) avoid impacts, 2) minimize impacts that are unavoidable, and 3) mitigate for unavoidable impacts. The OLF project is a required cleanup and remediation action under RFCA. Total avoidance of impacts to the wetlands is not feasible due to the remediation requirements. The wetland losses (1.24 acres) will be mitigated through the use or purchase of wetland banking credits. NOTE: The actual number of acres of wetland disturbed will be mitigated should the actual amount of disturbance be different from that described. If based on the final design of the toe of the landfill slope, it is possible to re-establish the wetlands at that location, the possibility of in-situ wetland re-creation may be evaluated. This would involve contouring the disturbed areas to re-establish the stream channel and then revegetating the area with native wetland/riparian species by seeding, using potted materials, or planting stakes or poles. However, at the present time, the final design of the cover is not available and so it is not possible to evaluate this possibility in any detail.

Mitigation Goals and Objectives

1. Mitigate OLF wetland impacts through the use or purchase of wetland mitigation bank credits (mitigation ratio = 1:1). The total wetland acreage to be mitigated for is estimated to be approximately 1.24 acres.

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Rationale for Choice

Given the lack of detailed plans and uncertainty of what will occur along Woman Creek at the bottom of the OLF project area and the permanent loss of wetlands under the OLF cover, the use of wetland mitigation bank credits is the preferred approach.

Mitigation Bank Approach

The first mitigation bank option may use the DOE's Standley Lake wetland mitigation bank for credits to offset wetland impacts in the OLF area. This bank was constructed several years ago by the DOE for use to offset wetland damages at Rocky Flats. At the time of writing, however, the Standley Lake bank had not been certified officially by the EPA although it is expected that this certification will occur soon. If the Standley Lake wetland bank credits cannot be applied to the OLF, then purchase of wetland bank credits from an off-site wetland mitigation bank will be necessary. A mitigation ratio of 1:1 will be used for use or purchase of wetland bank credits from either bank. Two potential commercial wetland mitigation banks that are present along the Front Range of Colorado are listed below.

Potential Off-Site Commercial Wetland Mitigation Banks

Middle South Platte River Wetland Mitigation Bank, Erie, CO
Banker: Land and Water Resources, Inc., 9575 W. Higgins Rd., Suite 470, Rosemont, IL 60018
John Ryan, Ph. 708-878-3903
Mitigation credits were still available as of June 2002. Cost: 60K to 80K+ per acre, variable depending on number of acres purchased.

Mile High Wetland Bank, Brighton, CO
Banker: Mile High Wetland Group, LLC, 80 South 27th Ave., Brighton, CO 80601
Laurie Rink, Ph. 303-659-7002
Mitigation credits are available as of July 2002. Cost: $80,000 per acre, with some decrease for volume purchases.

The wetland acres disturbed (debits) will be tracked in the Site's wetland debit/credit spreadsheet. The use of any wetland mitigation banking credits will also be tracked in the spreadsheet. NOTE: The actual number of acres of wetland disturbed will be mitigated should the actual amount of disturbance be different from that described.

Project Funding

Funding for the project is being provided by the DOE as part of the Site cleanup and closure activities that are being directed and overseen by Kaiser-Hill Company, L.L.C.

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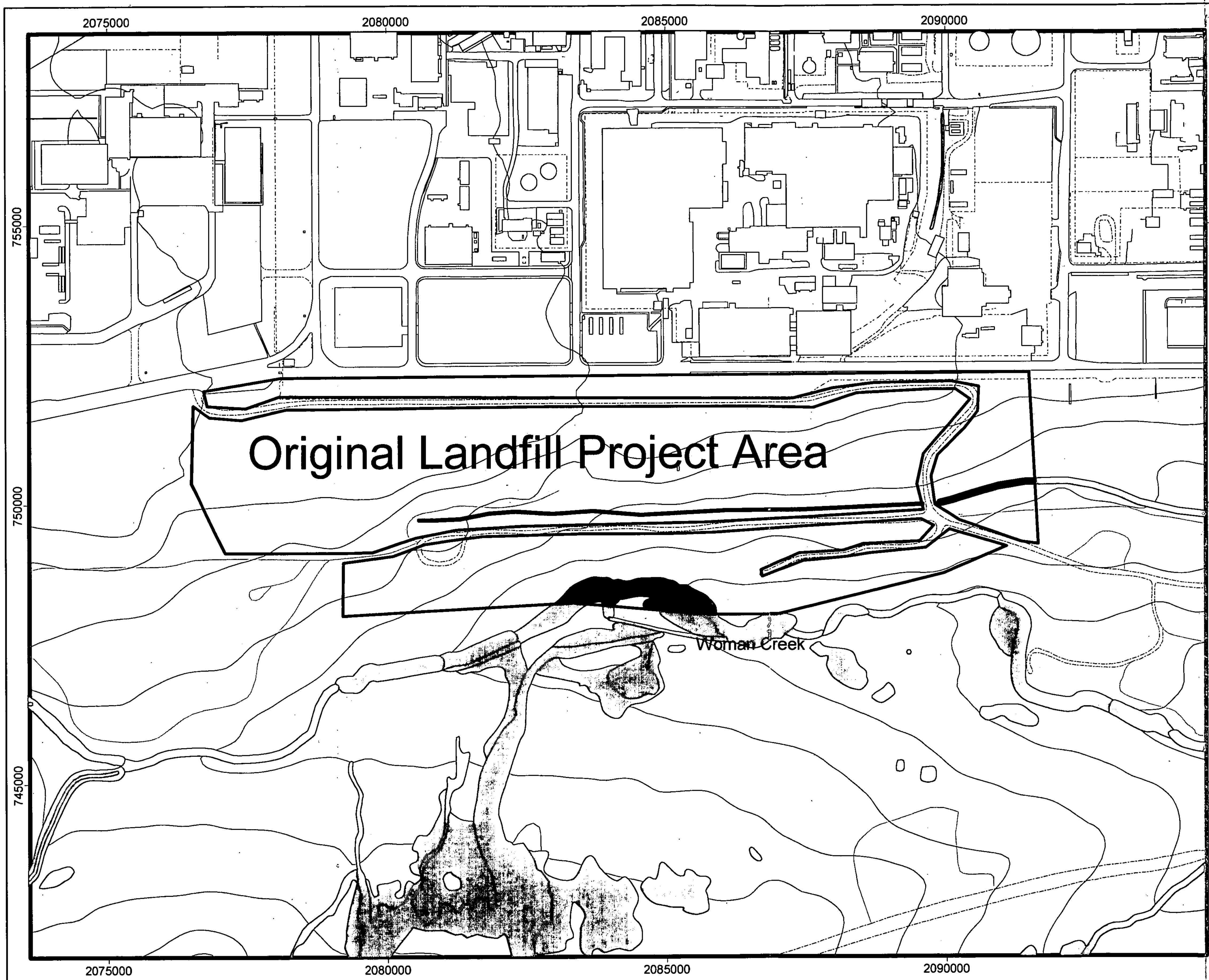

Original Landfill Project Wetland Impacts

Figure 1

Legend

- Original Landfill Project Footprint
- Jurisdictional Wetlands w/in project footprint COE 1994)
- Jurisdictional Wetlands adjacent to project footprint COE 1994)

Standard Features

- Buildings
- Demolished Buildings
- Lakes & ponds
- Streams & ditches
- Fences
- Paved roads
- Dirt roads
- Contours (20 ft. intervals)

DATA SOURCE BASE FEATURES:
Buildings, fences, hydrography, roads and other structures from 1994 aerial fly-over data captured by EG&G RSL, Las Vegas.
Digitized from the orthophotographs, 1/95.

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N

100 0 100 200 Feet

State Plane Coordinate Projection
Colorado Central Zone
Datum: NAD27

U.S. Department of Energy
Rocky Flats Environmental Technology Site

Prepared by: Professional Environmental Group, L.L.C.

For: Kaiser-Hill Company, LLC

RFETS GIS Dept.
303-966-7707

MAP ID: 04-0016

October 28, 2004

Q:\Projects\FY2004\04-0016\OLF wetland impacts 04.apr

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Appendix F

Comment Responsiveness Summary

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Integrated Flow and VOC Fate and Transport Modeling for the Original Landfill

Rocky Flats Environmental Technology Site, Golden, Colorado

TECHNICAL MEMO

Environmental Restoration
Rocky Flats Environmental Technology Site

December 2004

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Integrated Flow and VOC Fate and Transport Modeling for the Original Landfill at the Rocky Flats Environmental Technology Site, Golden, Colorado

Technical Report

December 6, 2004

By

Integrated Hydro Systems, LLC

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Executive Summary

Development and results of integrated flow and Volatile Organic Compounds (VOC) fate and transport modeling to support the Original Landfill (OLF) Interim Measure/Interim Remedial Action (IM/IRA) document are described in this technical memorandum. The integrated hydrologic flow code MIKE SHE is used to simulate conditions that develop for closure configurations because system flows are complex, and realistic closure configuration model parameter values can be assigned in the physically-based code. Development of the integrated flow model follows an approach similar to that used in former Site-Wide Water Balance (SWWB) integrated flow modeling (KH, 2002), where saturated and unsaturated flows are dynamically coupled with overland and channel flows. Development of the fate and transport modeling follows the approach used in more recent modeling to support the Comprehensive Risk Assessment (KH, 2004) where a reactive transport code is used to simulate attenuation processes such as degradation, sorption, dispersion and diffusion.

The primary objective of the flow modeling involves simulating integrated flow conditions within the OLF for four closure configurations. In addition, the fate and transport of elevated levels of VOCs within the OLF are modeled to estimate a range of long-term groundwater concentrations at possible surface water discharge locations. The four OLF closure configurations considered include the following:

- Scenario 1 - IA reconfiguration, no OLF modifications;
- Scenario 2 - IA reconfiguration, OLF regrade (basecase);
- Scenario 3 - IA reconfiguration, OLF regrade, buttress fill, and drain;
- Scenario 4 - IA reconfiguration, OLF regrade, buttress fill, drain, and slurry wall.

These objectives are addressed in several steps. First, available geologic, hydrologic and chemical data, including recent water levels and geotechnical information, are compiled into a Graphical Information System (GIS) to conceptualize flow within the OLF. A localized, fully-integrated flow model is then developed for the OLF area based on these data for current conditions to demonstrate that parameter values are appropriate for simulating closure configurations. The integrated model is modified to simulate the hydrologic changes to the system for each of the four closure configurations. Finally, fate and transport of elevated levels of PCE and its daughter products are conservatively evaluated from inferred constant concentration source areas within the OLF using a reactive transport code.

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Current Configuration Data Evaluation

Several observations can be made from evaluation of available hydrologic data that are relevant to the geotechnical stability analysis:

1) Evaluation of historical groundwater level data in the OLF area indicates groundwater levels above the weathered bedrock range from 0 to 10 feet over about two thirds of the waste extent, while the levels are actually below the bedrock over the remaining one third.
2) For current conditions, average annual observed groundwater depths throughout the OLF area vary from over 20 feet depth at the top of the hillslope to less than 3 feet near Woman Creek and in shallow bedrock areas within the OLF.
3) Seasonal levels vary from 5 to 10 feet within the OLF.

Integrated Flow Model Development and Performance

The integrated flow model developed uses a much finer grid resolution of 25 feet than the former SWWB model to more accurately simulate the spatial variability of factors that affect flows in the OLF such as permeability distributions, surface topography and the weathered bedrock surface. The model only considers the Upper Hydrostratigraphic Unit (UHSU) material, but this unit is subdivided into four distinct layers that differentiate the OLF waste, fill material, native soils and the underlying weathered bedrock. Flow through the unsaturated zone is simulated using USGS mapped soils distributions and the current waste extent. Overland flow simulated in paved areas, or in unpaved areas when precipitation rates exceed the infiltration rate of the soils, is then routed into surface channels where it dynamically interacts with subsurface flows, or exits the model. The model also includes spatially distributed and time-varying inflow to channels from subsurface drains in the IA.

Results of model simulations for the current configuration using climate data from the year 2000 show that input parameter values reproduce average flow conditions well over the OLF. The model simulates average annual water levels within the OLF to within a foot of observed levels, and over the entire model area to within just over a foot with a standard deviation of less than four feet.

Closure Configuration Model Development and Simulation Results

Several model parameters are adjusted in the integrated flow model to simulate hydrologic effects of the closure configurations. In Scenario 1, adjustments are made to model input only in the IA. In the remaining scenarios adjustments are made to both the IA and OLF area. Closure modifications in the IA are similar to those assumed in the SWWB modeling (KH, 2002), where pavement and buildings are removed, subsurface drains are deactivated, and the surface of the

IA is regraded and revegetated. For scenarios 2 through 4, the surface topography in the OLF is regraded using a surface that is only preliminary and will be modified based on this modeling and geotechnical analyses. In scenario 3, a structural buttress fill extending to the weathered bedrock surface and an upgradient drain are assumed along the southern extent of the OLF. In scenario 4, a slurry wall extending to the weathered bedrock surface is placed upgradient of the OLF to simulate hydrologic effects of reducing lateral inflow from the IA into the OLF.

A typical climate sequence, based on year 2000 data developed in the SWWB modeling (KH, 2002), is reasonable for simulating flow conditions within the model because this sequence reproduces time-averaged (10 years) water levels well in the current configuration model. To support geotechnical stability analyses, a wet-year climate sequence (based on 100 years) is simulated for Scenario 2 to approximate conservatively high groundwater levels that develop within the OLF area.

Modeling results can be summarized as follows:

1) Model results show that reconfiguring the IA (Scenario 1) causes groundwater levels to increase less than one foot over the OLF. However locally, levels decrease less than 3 feet and increase up to 4 feet. Simulated depths are similar to current conditions and range from less than 5 feet to over 20 feet within the OLF.

2) Simulated effects of regrading the OLF and reconfiguring the IA (Scenario 2) for a typical climate sequence (WY2000) cause levels to increase an average of about two feet. Locally they decrease up to 3.5 feet and increase up to nearly 7 feet. This is due in part to the adjustments in evapotranspiration caused by changes in the depth to groundwater below the new regrade. Simulated groundwater depths vary throughout the OLF, mostly in response to 'fill' and 'cut' adjustments. At the western and eastern waste extents depths increase to near 40 feet due to increased fill thickness. Saturated heights above the bedrock increase from 3 to 7 feet over most of the OLF compared to Scenario 1.

3) Simulating a wet-year climate (100-year basis) sequence for Scenario 2 causes average annual groundwater levels within the OLF to increase about two feet (ranging from 0 to 4 feet over the OLF) compared to those for a typical climate sequence. Results also indicate that groundwater reaches ground surface in shallow bedrock areas, though this could be controlled by increasing the regrade surface height above bedrock. These simulated groundwater levels represent conservatively high levels that might be sustained for up to a month during a wet year climate sequence.

4) Simulated effects of adding a buttress fill and upgradient buttress drain (Scenario 3) cause average annual groundwater levels to decrease less than

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one foot over the OLF. However locally, the drain causes levels to decrease up to 3 feet over the southern half of the OLF. Levels near the drain decrease about 11 feet. Simulated annual discharge rates from the drain are less than 1 gpm.

5) Simulated effects of adding a slurry wall to Scenario 3 (Scenario 4) cause average annual groundwater levels over the OLF to change less than one foot. However levels downgradient (south) of the slurry wall decrease less than 3 feet, while those upgradient of the slurry wall (north) increase up to 3 feet within about 300 feet.

6) Results of the current and closure simulations conducted in this study indicate that surface regrading results in the largest impact on OLF groundwater levels. Modeling also shows that seeps may occur under wetter climate though this could be controlled by adjusting the surface regrade topography.

7) A sensitivity analysis to determine the most sensitive parameters controlling water levels in the OLF was not conducted in this study, though results suggest that the regraded surface, bedrock depth and waste area hydraulic properties are the most sensitive. An uncertainty analysis to assess the range of hydrologic response to input parameter value uncertainty was also not conducted in this study. As such, simulated responses could change depending on the specific parameter values used, though reasonable values were assumed.

Fate and Transport Model Development and Simulation Results

Only tetrachloroethene (PCE) and its daughter products are evaluated in this study because they are detected in the OLF. Average annual groundwater velocity field estimated using the integrated flow model for Scenario 1 and 3 are used as the basis for reactive transport modeling using the RT3D code.

Reactive fate and transport modeling of PCE (and daughter products) detected in groundwater in the OLF waste indicate that concentrations at Woman Creek remain well below surface water standards for both Scenario 1 and 3. More conservative fate and transport scenarios (most conservative parameter values) show that groundwater concentrations may reach the buttress drain at detectable concentrations, though they remain below the surface water standards. Results of the fate and transport simulations assume that the PCE source concentrations remain constant during any regrade of the area.

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1.0 Introduction

Results of integrated flow modeling and VOC fate and transport associated with the Original Landfill (OLF) flow system are described in this technical memo in support of the OLF Interim Measure/Interim Remedial Action (IM/IRA). Key factors affecting the stability of the proposed OLF closure configuration are groundwater levels and their fluctuations with time. Although current groundwater level data in the OLF area are useful in assessing spatial characteristics such as groundwater depths, flow directions, and fluctuations in time, they should not be used to assess these characteristics for closure configurations. As groundwater flow at RFETS is complex, 3-dimensional and depends on many factors, an integrated flow model, using a similar approach to that described in the Site-Wide Water Balance Modeling report (KH, 2002), is developed to assess flow conditions under both current (WY2000) and closure configurations. The fate and transport of VOCs detected in the OLF are assessed using an approach similar to that described in a recent VOC fate and transport modeling report (KH, 2004).

The objectives of the modeling are described in Section 1.1. The steps taken to meet these objectives are outlined in Section 1.2. A brief discussion of available data and an analysis of these data are presented next in Section 2, followed by a description of the development of the integrated flow model and simulated results for current conditions in Section 3. In Section 4, specific closure scenarios are outlined, assumptions are outlined, and results are summarized. VOC fate and transport modeling is described in Section 5. Finally, key steps in this study are summarized and conclusions outlined in Section 6.

1.1 Objectives

The objectives of the modeling include the following:

1) Simulate integrated flow conditions within and surrounding the OLF waste for the following closure configurations:

- *No modifications to current OLF system;*
- *Regrade OLF area and IA closure;*
- *Regrade OLF area and IA closure, structural buttress fill downhill of waste, and upgradient drain; and*
- *Same as above, but includes a slurry wall upgradient of waste.*

2) Assess the following:

- Change in groundwater levels for each closure configuration from current conditions; and

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- Change in groundwater depths.

3) Assess the fate and transport of VOCs:

1.2 Approach

Several steps required to meet the objectives above are outlined graphically on Figure 1-1. The approach used here in developing the integrated model for the OLF system is similar to that described in (KH, 2002). Current system flows are first simulated to demonstrate that assumed model parameter values reproduce observed flow conditions adequately. Then several model input parameters are adjusted to simulate the integrated hydrologic system response of the closure configurations. The MIKE SHE code, developed by DHI (1999), is used to simulate the integrated flows at the OLF because it is physically-based (uses non-empirical flow equations) and fully-integrated, coupling subsurface flows (unsaturated and saturated zone) with surface flows (overland and channel flow). Effects of evapotranspiration and snowmelt are also considered in the OLF integrated flow model, and scenarios are continuously simulated using spatially-variable sub-hourly climate input over a full year.

A sensitivity analysis was not performed in this study. However, previous integrated modeling (KH, 2002, and KH, 2004) showed that the weathered bedrock surface, surface topography and hydraulic conductivity distribution are among the most important parameters. An uncertainty analysis to assess effects of input parameter uncertainty was also not conducted in this study, though reasonable values were assumed. As such, simulated responses presented could change depending on the specific parameter values assumed.

An important step in the development of the integrated flow model for the current configuration was updating the existing GIS database, developing new surfaces with recent data, and incorporating this information into the integrated flow model through a series of database algorithms.

2.0 Available Data and Analysis

The OLF study area, waste extent, and existing surface topography are shown on Figure 2-1. Vertical profile locations are also shown that correspond with the locations cited in Metcalf and Eddy (1995). The Building 444/440/460 area north of the OLF was included in the study to consider hydrologic impacts of the closure on the OLF area.

Available geologic, hydrologic, and chemical data in the OLF and surrounding area were reviewed and compiled into a spatial Geographical Information System (GIS) database to support model development. Most of this information was obtained from former SWWB modeling (KH, 2002), though several new datasets were prepared specific to the OLF. For example, a more accurate ground

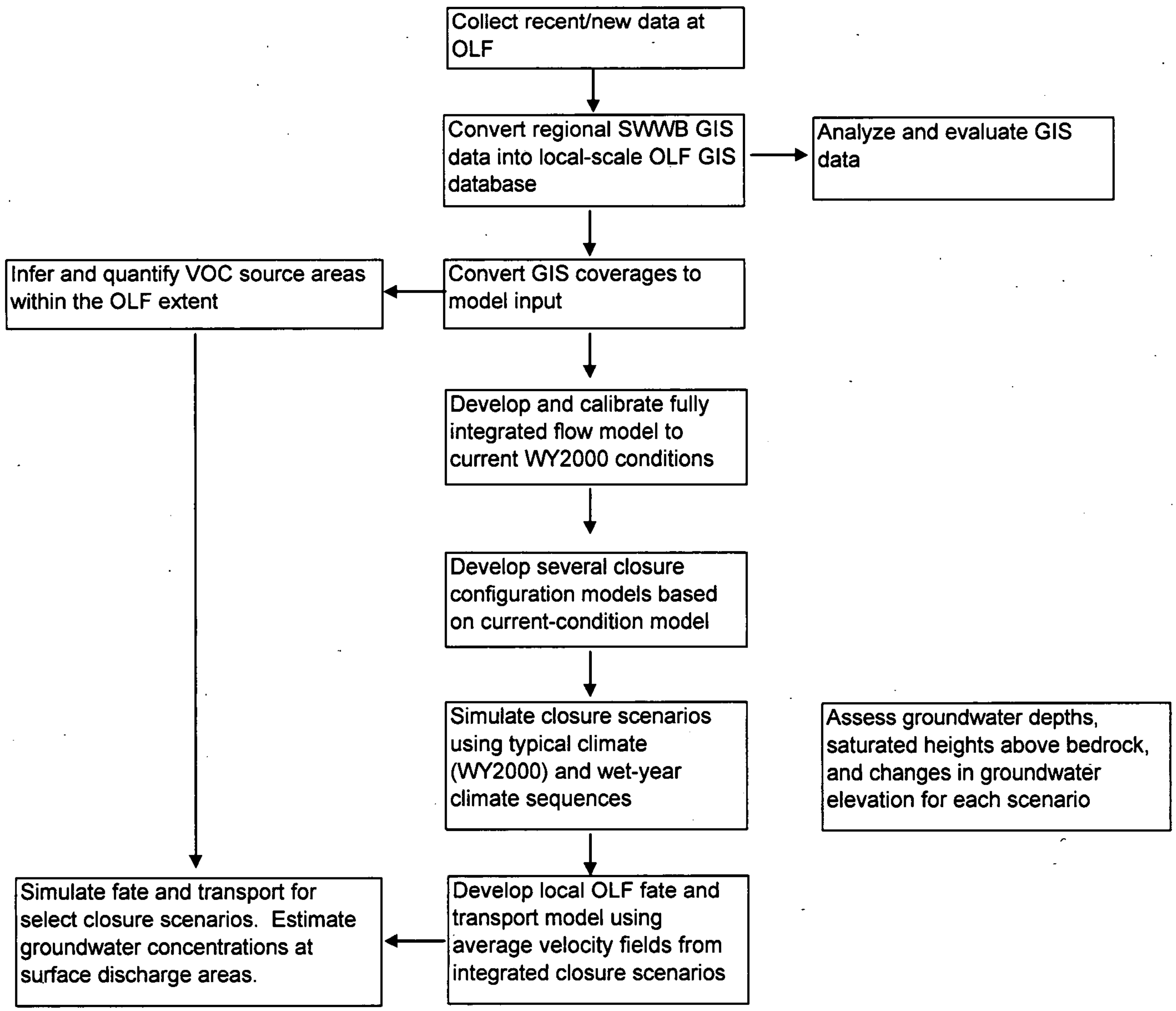

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Figure 1-1
OLF Modeling Approach

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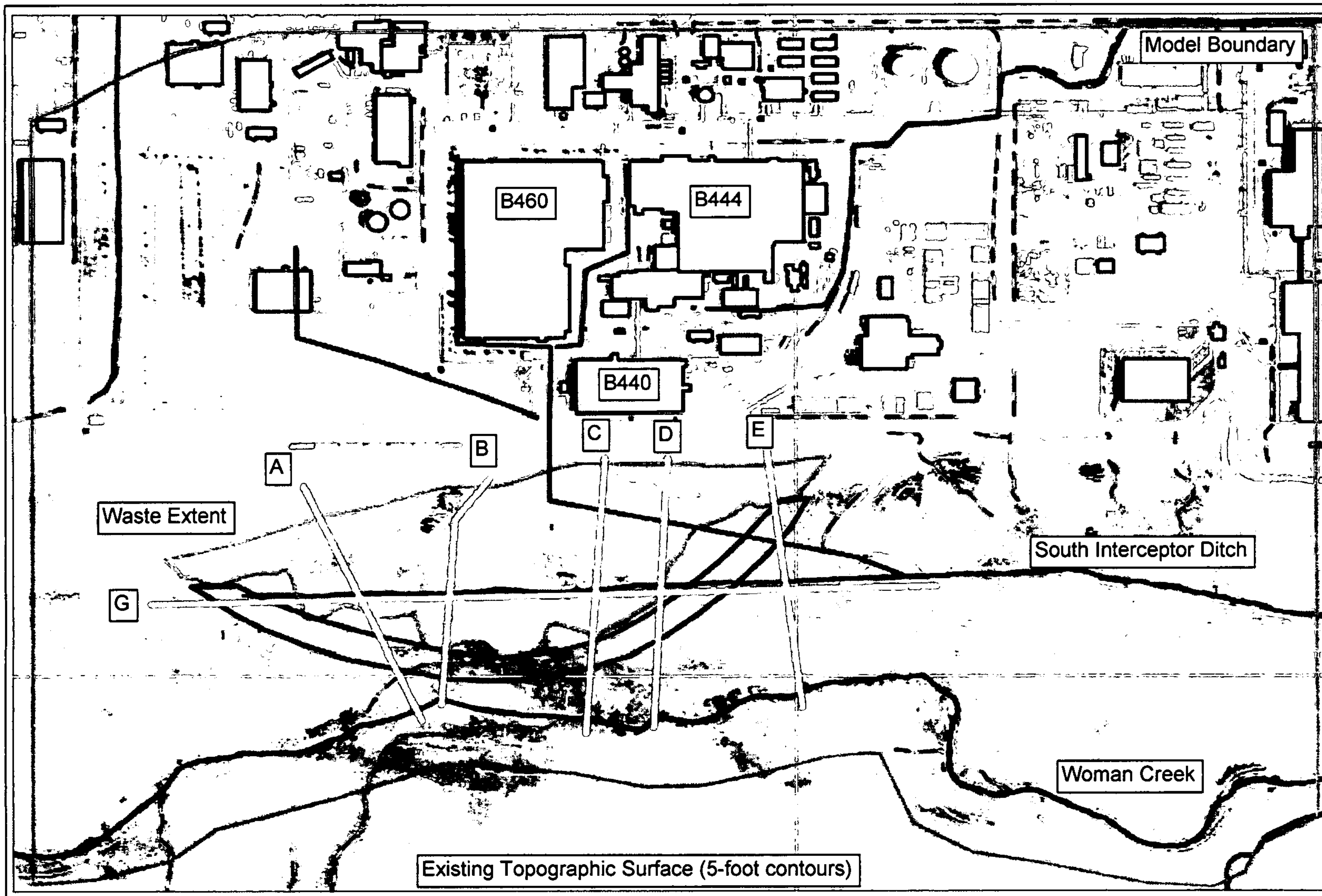

NOTE:

[A] Vertical Profile Location - Initially defined in Metcalf & Eddy Report (9/1995)

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Figure 2-1
OLF study area, waste extent, current surface topography, and vertical profile locations.

surface topography in the OLF area was obtained. In addition, all available field geologic borehole logs were reviewed to define approximate waste and bedrock surface contacts. Recent logs in the area, along with the higher resolution surface topography, were used to construct weathered and unweathered bedrock surfaces throughout the OLF area that are more accurate than previously approximated surfaces (KH, 2002). The refinement of the weathered bedrock surface is important as this was found to strongly control groundwater flow gradients and levels in hillslope areas.

Vertical profiles at lines shown on Figure 2-1 are illustrated on Figure 2-2. The existing topography, regrade surface, weathered bedrock, and unweathered bedrock are shown including approximate time-averaged groundwater levels determined through spatial interpolation. Thicknesses of unconsolidated material from the Building 440 area, south through the waste to Woman Creek, range from over 20 feet to less than 5 feet (Figure 2-3). Thickness of the waste material is also variable, ranging from less than 5 feet in the east-central area to more than 12 feet to the west. Unweathered bedrock thickness remains relatively uniform at about 20 feet through the OLF area.

More than 10 years of groundwater level data (Figure 2-4) in the OLF area, including recent 2004 data, were also reviewed and indicate several things. Groundwater levels in most wells within the OLF vary less than 5 feet annually, while surrounding, external, water levels typically vary between 5 to 10 feet over the year (some range from 10 to 15 feet per year, but are likely related to increased recharge from snow removal and mounding), reflecting seasonal recharge, evapotranspiration and drainage effects. The difference in magnitude of groundwater fluctuations between the two areas suggests that unsaturated and saturated zone hydraulic properties of the waste area may differ somewhat from non-waste areas.

Groundwater depths (Figure 2-5) in the Upper Hydrostratigraphic Unit (UHSU) decrease from about 20 to 30 feet below ground near the Building 440 area on the mesa to about 15 feet below ground within the waste, to less than about 5 feet below ground along Woman Creek. In Lower Hydrostratigraphic Unit (LHSU) wells in the OLF area groundwater depths are significantly lower than in nearby UHSU wells (57194, 71194 are greater than 100 feet, indicating that the LHSU and UHSU are hydraulically disconnected in the area.

Finally, a potentiometric surface map, constructed using time-averaged water level information, indicates a west-east groundwater divide just north of the Building 444. Therefore, groundwater south of this divide eventually flows towards Woman Creek.

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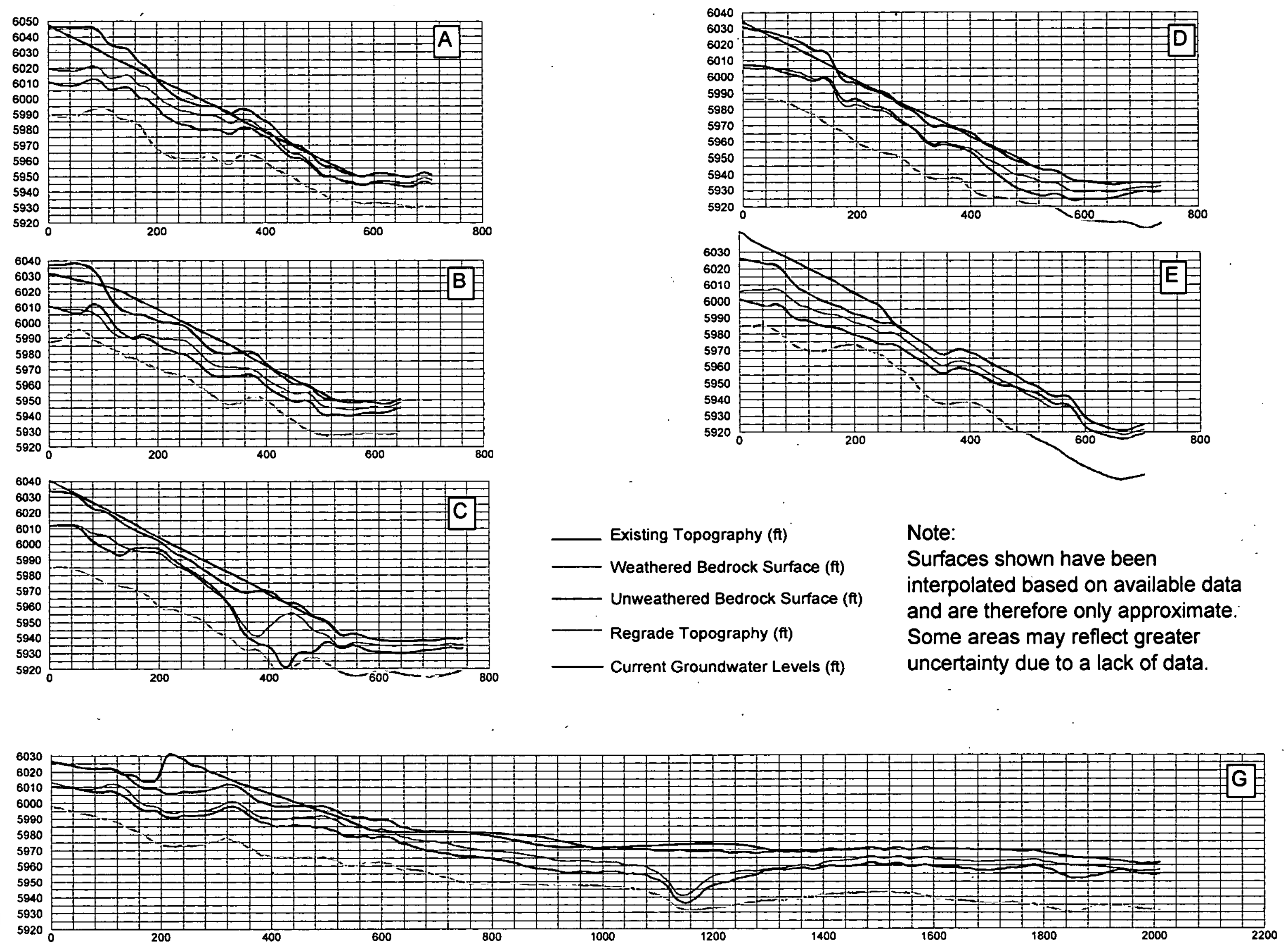

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Figure 2-2
Vertical profiles of hydrostratigraphy

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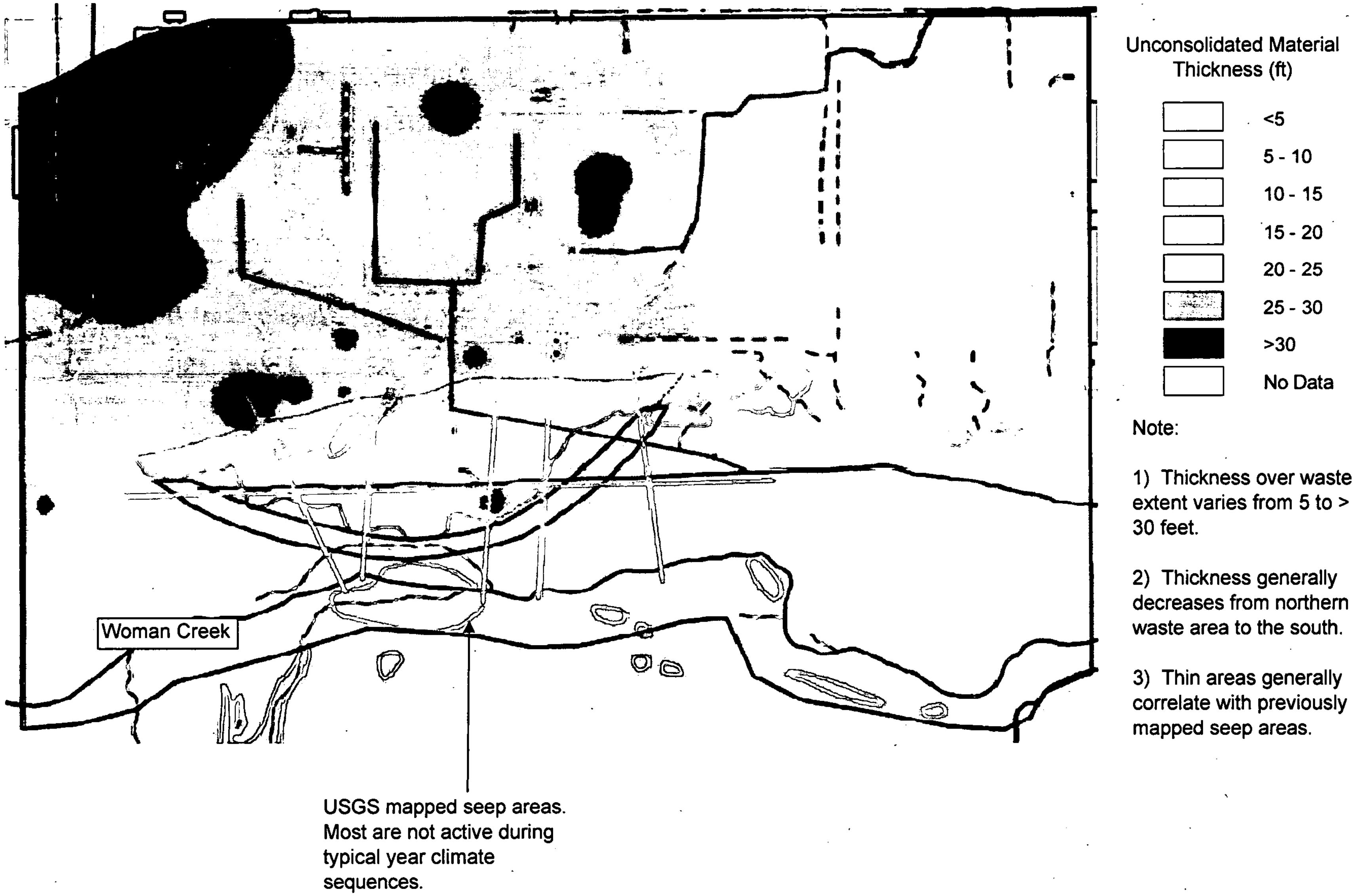

Figure 2-3
Approximate thickness of unconsolidated material (depth to weathered bedrock), (ft).

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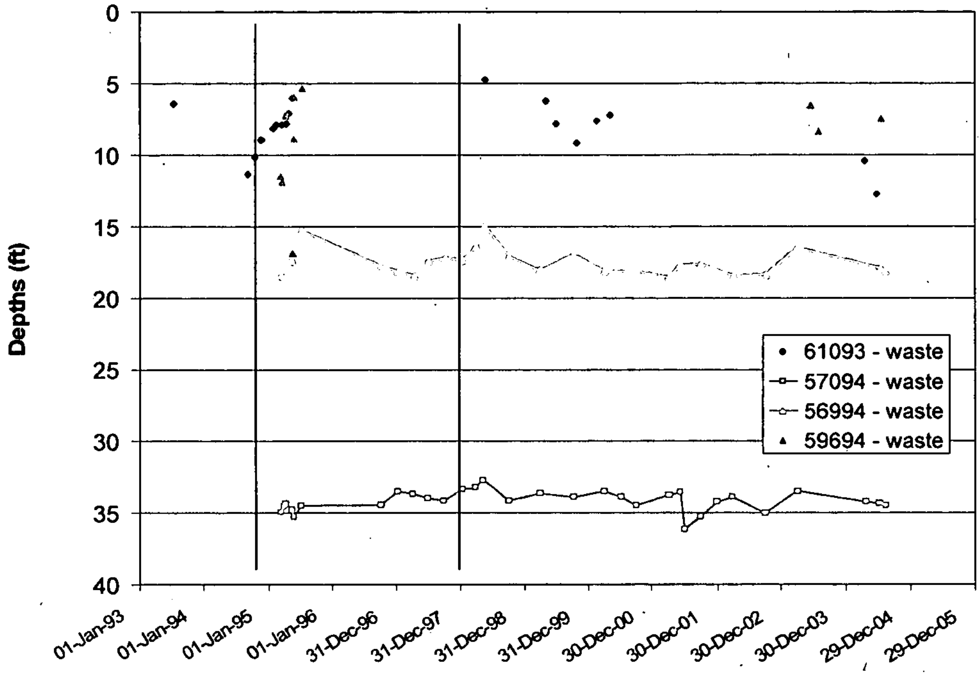
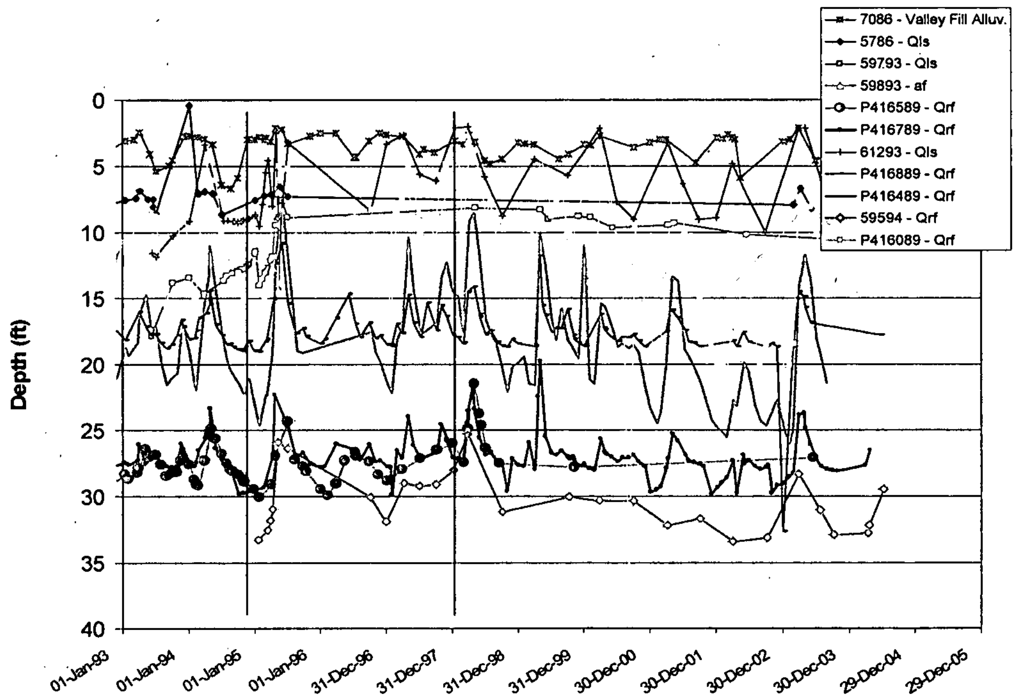


Waste area groundwater depths (ft)



Non-Waste area groundwater depths (ft)

Figure 2-4
Waste area and non-waste area groundwater depths with time (feet)

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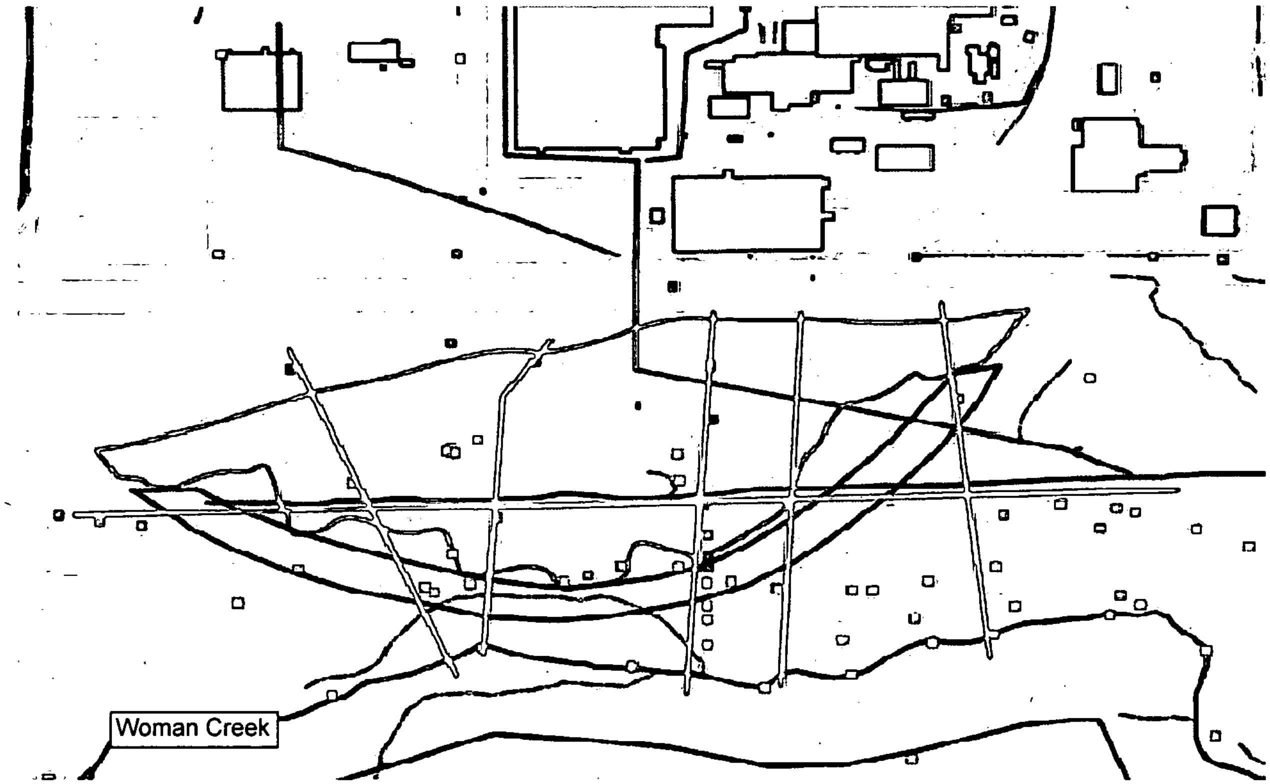

Time-averaged Groundwater Depths (ft) below ground surface at well locations

- 1 - 5
- 5 - 10
- 10 - 20
- 20 - 30
- 30 - 99.296

Note:

1) Several locations shown along Woman Creek are control points used in defining initial conditions for the integrated flow model and are not wells.

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Figure 2-5
Time-averaged groundwater depths in OLF study area

3.0 Integrated Model Development and Performance for Current Conditions

3.1 Integrated Model Development

Constructing the integrated flow model involved several steps. First, the integrated flow model is based on a 25-foot numerical grid, as shown on Figure 3-1, to better simulate local flow conditions associated with the OLF (the SWWB model used a 200-foot grid resolution). Several GIS techniques were used to convert spatial hydrogeologic GIS information onto the finer grid. Spreadsheet algorithms were then used to convert gridded GIS information into model input. Figure 3-2 shows modeled utility corridors and drain distributions and Figure 3-3 shows modeled vegetation and unconsolidated soil distributions in the OLF area. These are examples of OLF GIS coverages converted into model input.

The saturated portion of the model is specified using four layers, the upper two for unconsolidated materials and drains, and the lower two for weathered bedrock. At each model cell, an unsaturated zone column is discretized into more than 100 cells to describe the non-linear dynamics including infiltration, depth-varying evapotranspiration, redistribution, and eventually groundwater recharge (using a full Richard's based equation). Overland flow and channel flow are simulated like in the SWWB modeling. Unsaturated and saturated zone hydraulic properties determined through integrated model calibration conducted for the original SWWB model and subsequent VOC fate and transport modeling (KH, 2004) were specified in the OLF model. However, new values for drain conductances and hydraulic properties for the waste were determined through initial OLF model simulations.

3.2 Model Performance – Current Conditions

The integrated model of the current system configuration, using climate data from October 1999 through September 2000, reproduced observed flow conditions well. Model simulations require that the WY2000 climate sequence is cycled for three consecutive years to stabilize effects of prescribed initial conditions. Model performance is assessed by comparing time-averaged simulated and observed water levels at wells throughout the model area (Figure 3-4). Results indicate that the model simulated time-averaged heads are within 3 feet in most locations. This is considered good given the complexity of flows in the area and change in topographic relief over the model area. Furthermore, residuals appear to decrease to within 3 feet from the upper waste area to Woman Creek. In some areas, levels are over-estimated between 3 to 7 feet. This discrepancy can be explained by an underestimation of drain discharge in the area, increased localized recharge due to runoff from paved areas into unpaved areas, or the reduced groundwater discharge to channels. These factors become unimportant in closure configurations.

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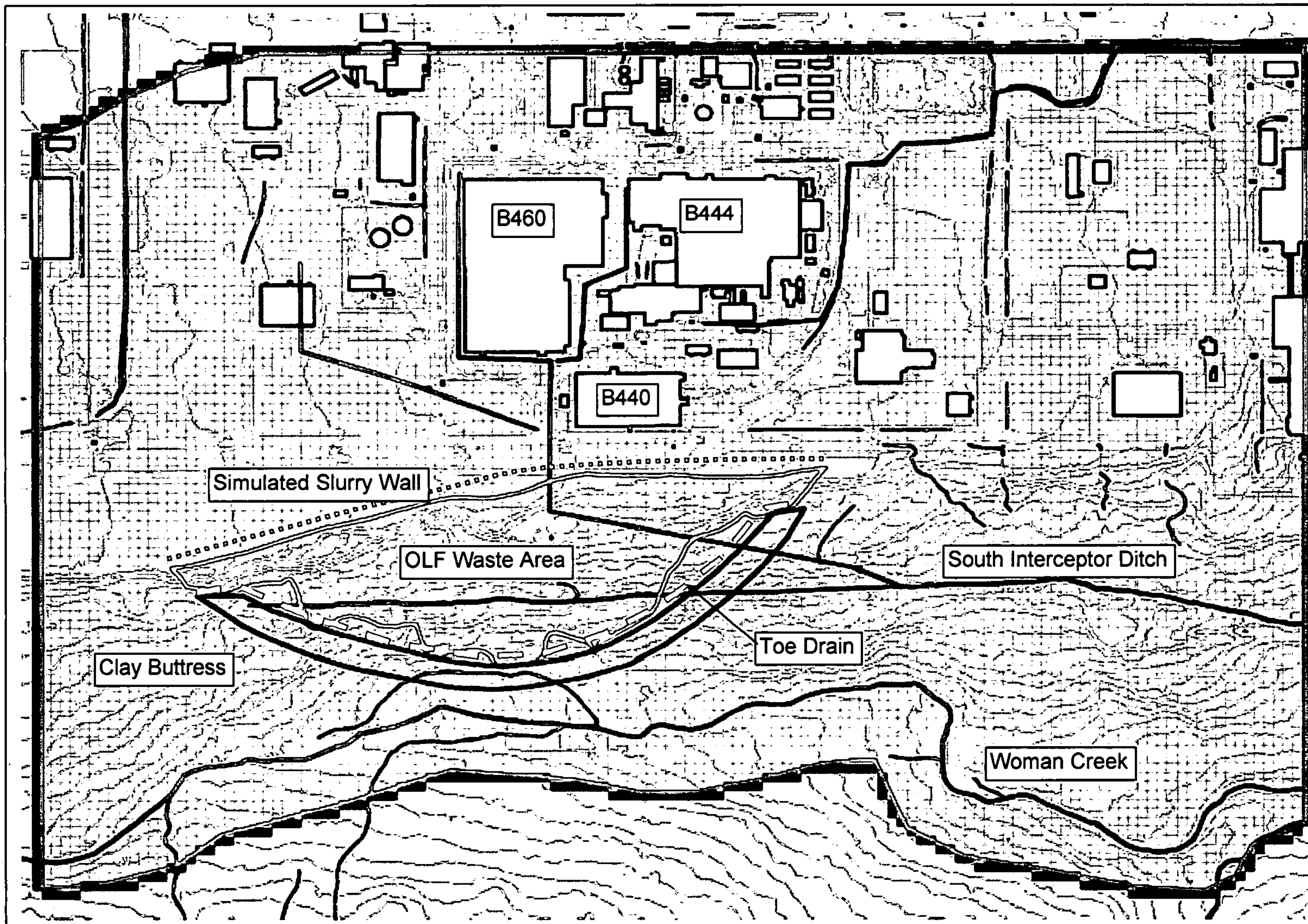

Note:
1) MIKE SHE grid spacing is 25 feet.
2) Slurry wall, Buttress Fill and Drain only shown here for reference (only occur in closure configuration).

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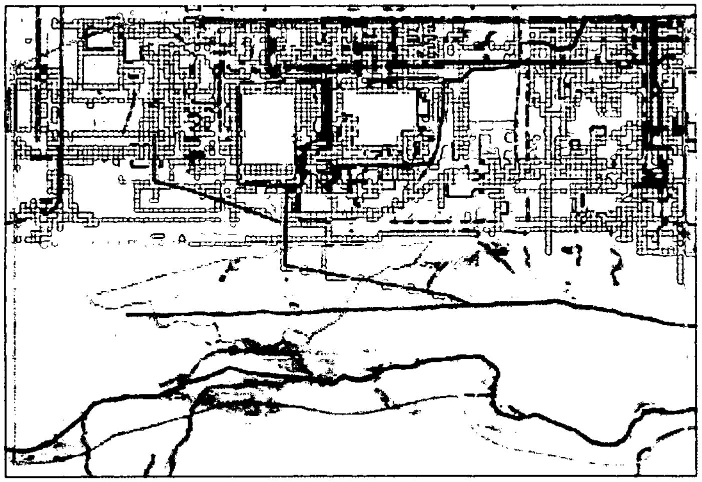
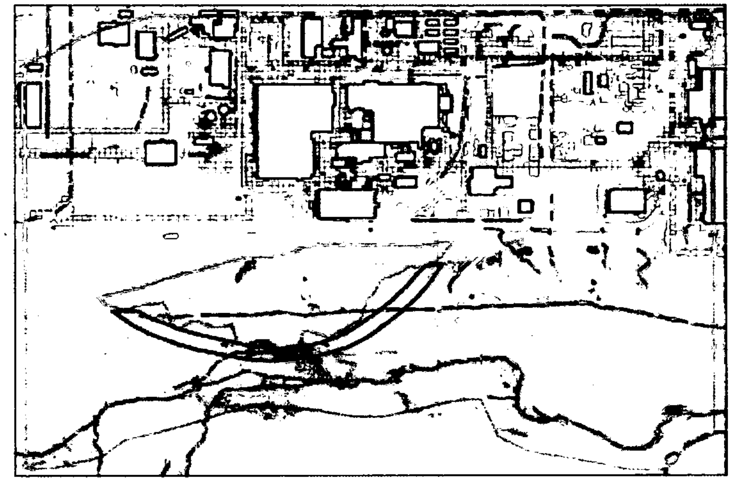
Figure 3-1
Integrated Flow Model Grid and Boundary



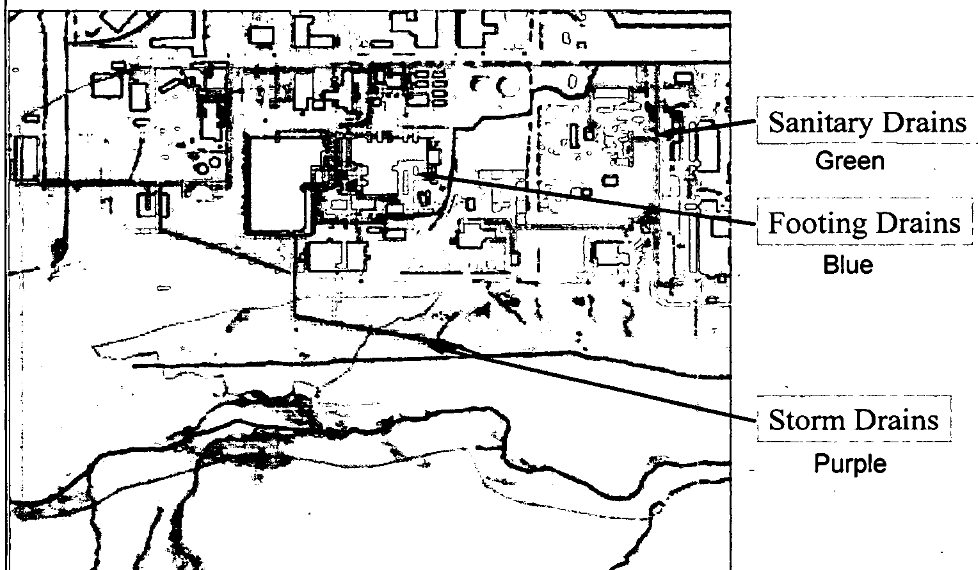
Subsurface Utility Corridors

(Preferential Pathways)



Water Supply Lines

(Aquifer Recharge)



Note:
1) Color variation shown on two upper plots reflect density of utility corridors or water supply lines within each model cell (25 feet dimension). Darker colors indicate greater densities.

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Figure3-2
Simulated Utility Corridors and Subsurface Drains

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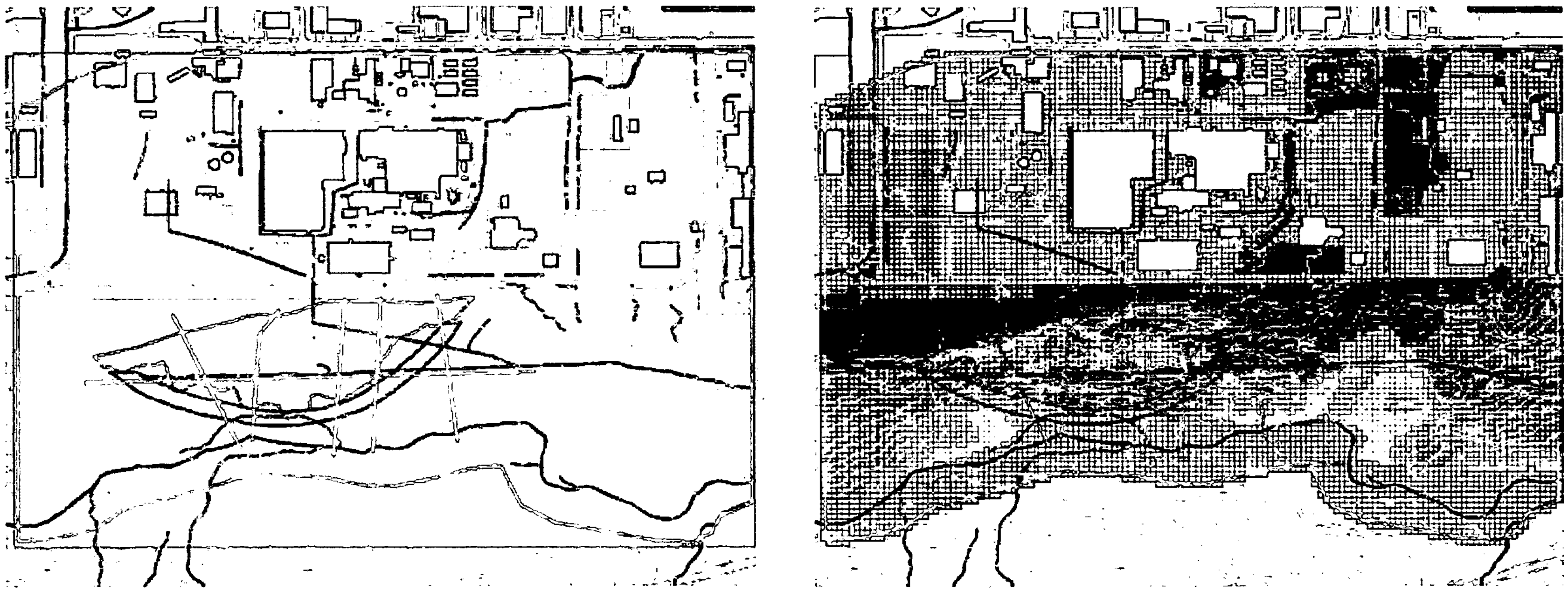


Vegetation Distributions

Unconsolidated Soil Distributions

NOTE:

1) Colors represent major vegetation zones
2) Six major vegetation zones defined
   - -mesic
   - -xeric
   - -riparian
   - -wetland
   - -paved areas (only surface evaporation-interception)
   - -dirt areas (only evaporation)

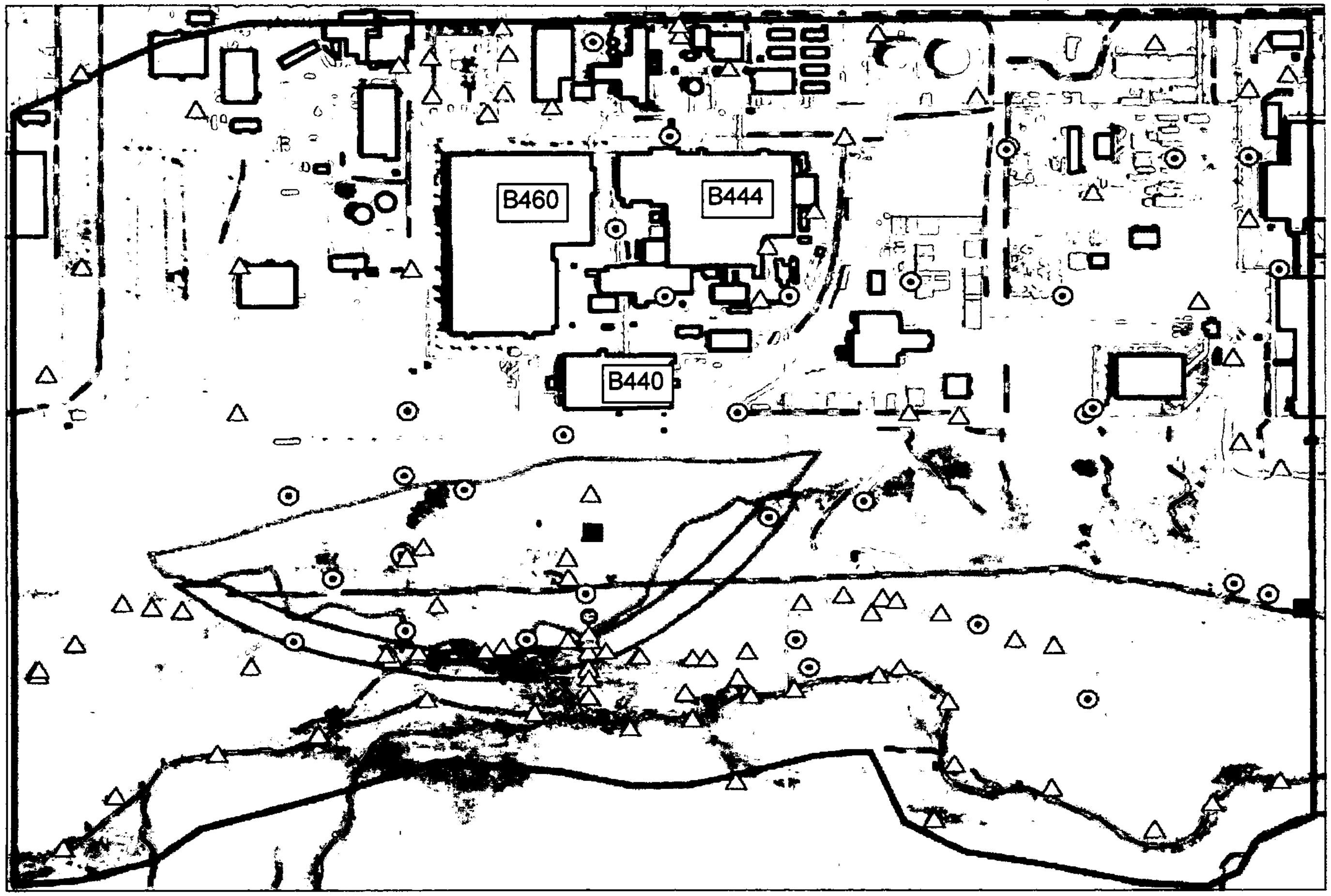
NOTE:

1) Twenty-eight soil zones defined to simulate flow through the unsaturated zone.
2) Major distribution defined by USGS surficial material definitions (i.e., Qrf, Qls, Qp, Qc, Qt, Qp, and Qls),
3) Within major distributions, soil types further subdivided based on depth to bedrock (5-foot depth increments).

General Note:

1) The vegetation and unconsolidated soil distributions are only shown here to indicate the resolution and spatial variability included in the integrated flow model. Refer to the SWWB modeling report for more detailed description based on field mapping (KH, 2002).

Figure 3-3
Model Input -
Soil and Vegetation Distributions



Simulated minus observed groundwater depths (feet).

- < -3
- -15 - -10
- -10 - -4
- -4 - 4
- 4 - 10
- 10 - 15
- > 3

Note:

1) Negative (red) difference denotes model under-simulates groundwater levels.

2) Positive (blue) denotes model over-simulates groundwater levels.

Figure 3-4.
Difference between simulated and observed time-averaged groundwater depths

Simulated annual surface flow at gage GS22, though less than observed indicates most surface events are captured in peak flow, timing of events, snowmelt, and baseflow. Additional adjustment of drain conductances would likely improve the comparison between observed and simulated surface flows. However, the drain conductances are unimportant in evaluating impacts of closure configurations on system flows as the drains are removed in these simulations.

Figure 3-5 and 3-6 show the simulated annual average groundwater depths based on the existing topography and the simulated average annual saturated heights above the weathered bedrock surface, respectively. Simulated depths are quite variable over the OLF model area. Depths range from 7 to 10 feet north of Building 440/444/460 area to greater than 20 feet at the top of the slope and then decrease to 3 to 7 feet near Woman Creek. Saturated heights above the weathered bedrock, important to the stability analysis in the waste area, only range from 5 to 10 feet in the west-central area, and are actually unsaturated in the east-central area.

4.0 Closure Configuration Integrated Flow Model Development and Simulation Results

4.1 Closure Configuration Scenarios

Changes to the integrated hydrologic flow regime at and surrounding the OLF were evaluated for several different closure configurations. For each of the closure configurations, it is assumed that the configuration in the Industrial Area (IA) (north of the OLF) undergoes modifications consistent with those described previously in both the SWWB modeling (KH, 2002) and more recent VOC fate and transport modeling (KH, 2004). The only differences in the IA closure configuration from these previous evaluations are the surface topography and drainage. These were updated during August 2004 and are used in this analysis. Major assumptions in the IA closure configuration are briefly summarized below. Specific OLF-related changes are described next for each scenario.

Key IA Closure Configuration Assumptions include the following:

- Buildings are removed, but basements for B444 are assumed to remain;
- Pavement removed;
- Sanitary, storm and footing drains deactivated;
- Leaky water supply lines deactivated;
- Surface topography regrade (over IA); and
- Surface drainage modifications.

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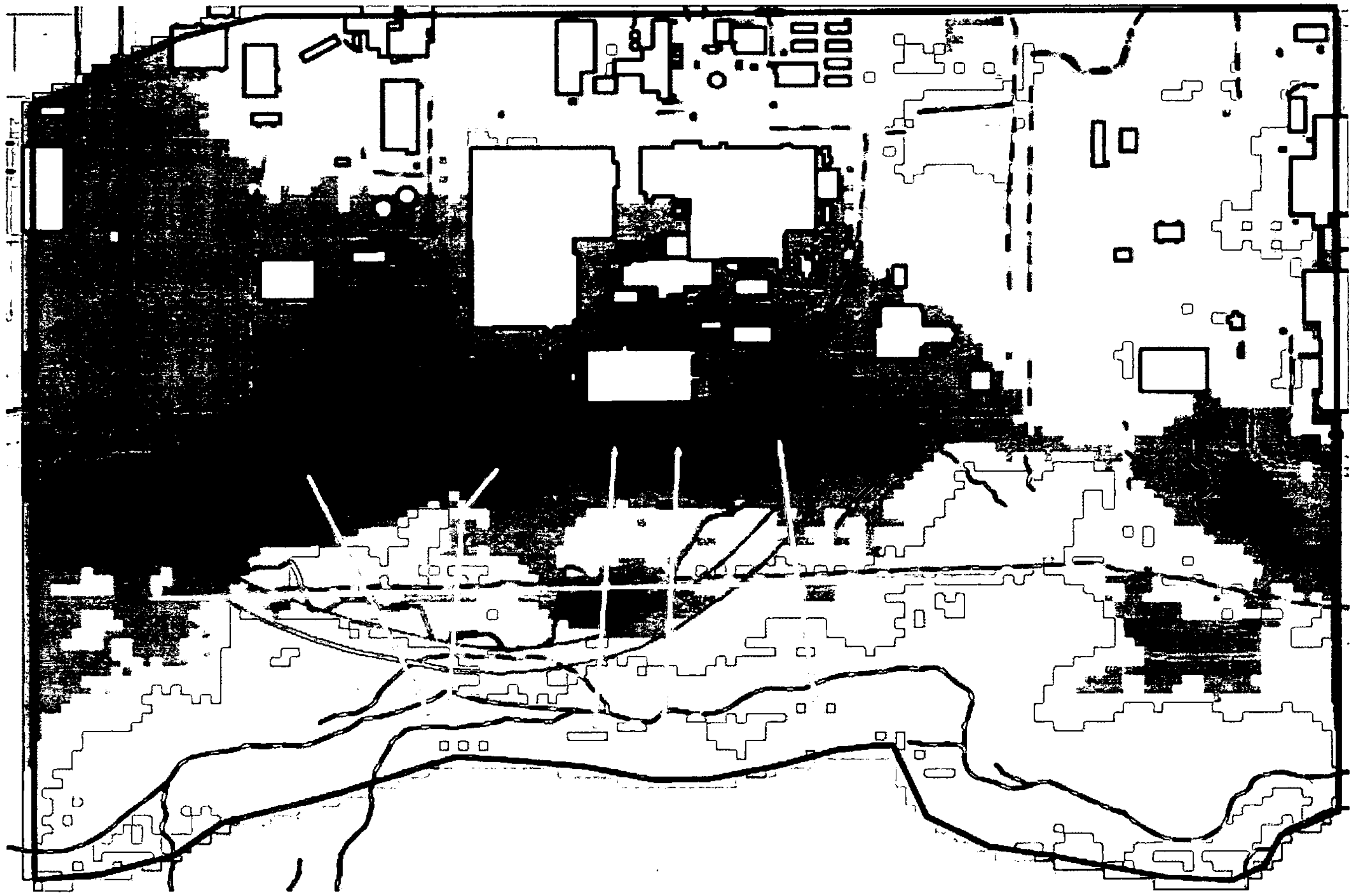

Simulated average annual groundwater depths (feet).

- -10 - 0
- 0 - 5
- 5 - 10
- 10 - 15
- 15 - 20
- 20 - 45

Note:

1) Negative numbers (yellow) indicate groundwater levels are above ground surface. These areas represent seeps or baseflow.

2) Average annual levels are calculated from simulated levels calculated every 6 hours over WY2000 (October 1999 to 2000).

Figure 3-5
Current Conditions - Simulated (Typical Climate) average annual groundwater depths (ft)

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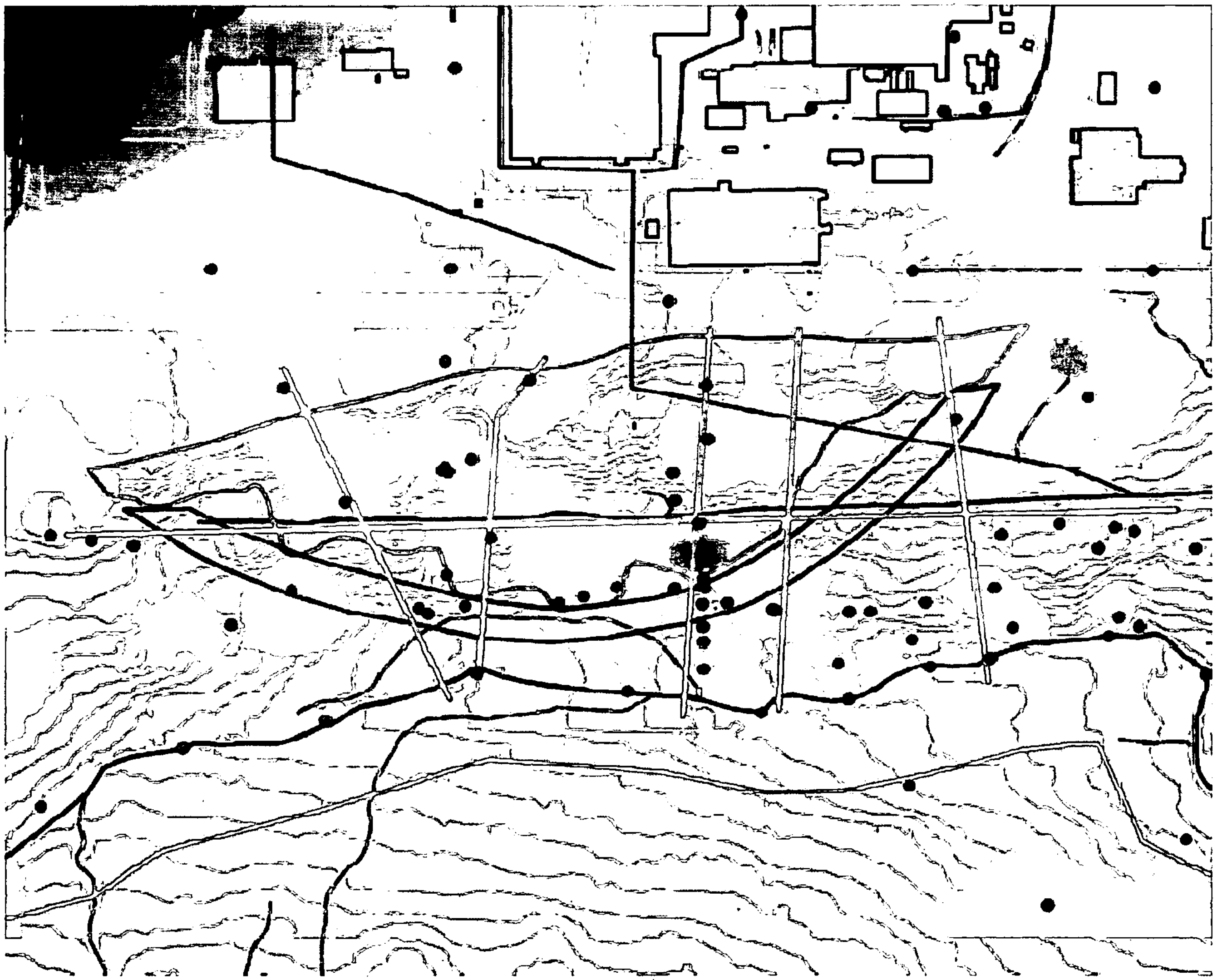

Calculated average annual groundwater height above weathered bedrock (feet).

- -15 - -10
- -10 - -5
- -5 - 0
- 0 - 5
- 5 - 10
- 10 - 15
- 15 - 20
- 20 - 40
- No Data

Note.

1) Saturated heights calculated by subtracting simulated average-annual groundwater levels from the weathered bedrock surface.

2) Negative numbers indicate areas where groundwater levels are below weathered bedrock.

3) Positive numbers indicate saturated groundwater heights above the top of the weathered bedrock surface.

Figure 3-6
Current Conditions - Simulated (Typical Climate) average annual saturated height above Weathered Bedrock surface (ft).

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***Scenario-specific Closure Configurations and Assumptions include the following*:**

- **Scenario 1 – IA Regrade-only**
  - IA undergoes closure configuration (as per above);
  - No changes made to existing OLF area; and
  - Typical climate year sequence assumed (WY2000).
- **Scenario 2 – IA & OLF Regrade (basecase)**
  - IA undergoes closure configuration (as per above);
  - OLF area is regraded;
  - OLF area is re-vegetated;
  - Fill material is used as part of regrade (assume Qrf); and
  - Typical and Wet Year (100-year basis) climate year sequence assumed.
- **Scenario 3 – IA & OLF Regrade, Buttress fill, Buttress drain**
  - Same as Scenario 2;
  - Includes Buttress fill and Buttress drain on Upgradient side; and
  - Typical climate year sequence assumed (WY2000)
- **Scenario 4 – IA & OLF Regrade, Buttress fill, Buttress drain, and Slurry Wall**
  - Same as Scenario 3, but includes slurry wall immediately north of the waste area footprint.

In the 'basecase' OLF closure configuration scenario (Scenario 2), both the IA and OLF are reconfigured. To the north of the OLF, the IA is closed as described in the VOC Fate and Transport integrated modeling (KH, 2004). Pavement, buildings, drains and water supply lines are removed, the IA is regraded, and then re-vegetated. Over the OLF area, only the ground surface is regraded and re-vegetated.

Three-dimensional perspective views of the current, regrade, and weathered bedrock surfaces are shown on Figure 4-1a. The change in surface topography and unconsolidated material thickness is shown on Figure 4-1b. Two notable changes occur in the OLF area that cause notable changes in local hydrologic flow conditions. First, the regrade results in increases in unconsolidated thickness up to 30 feet, and decreases up to 20 feet. This in turn increases and decreases the depth to the weathered bedrock from the new regrade. These changes cause groundwater level adjustments throughout the waste area described further in Section 4.2.

995

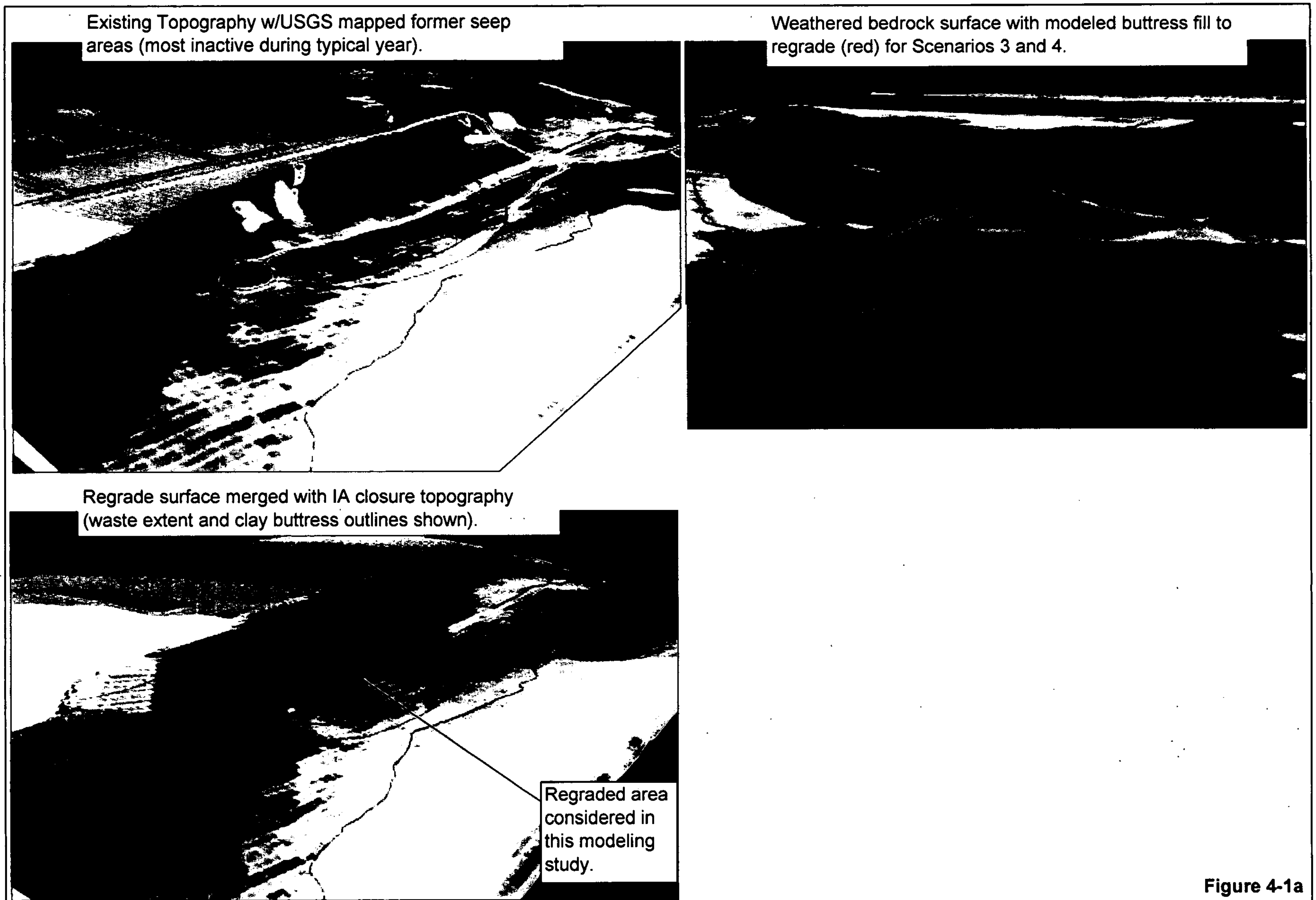
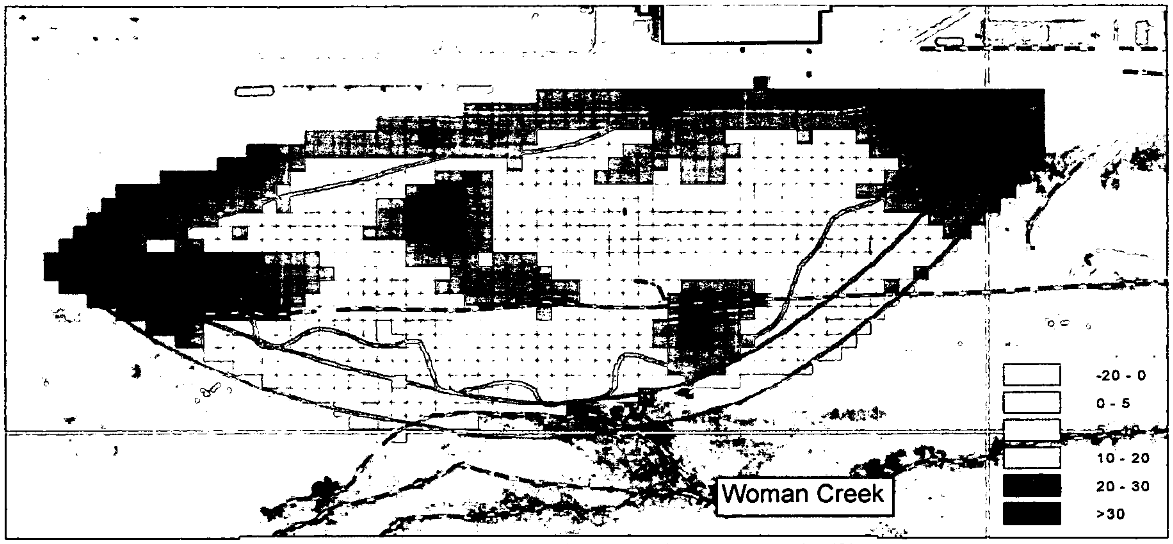
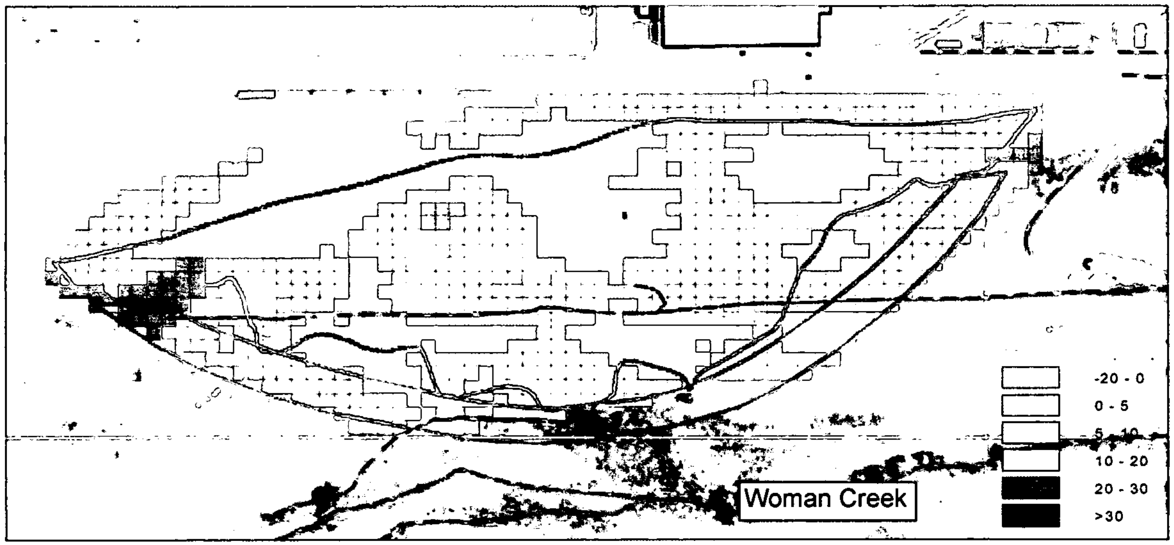


Figure 4-1a
Current, regrade and bedrock surface 3-dimensional perspective views

597



Change in unconsolidated thickness due to regrade (ft).



Change in surface topography (Regrade surface minus existing surface).

Note:

1) Thicknesses shown in feet.

2) Change in surface topography results in greater fill areas and volume than cut areas.

3) Positive numbers indicate increase in thickness. Negative numbers indicate a decrease in thickness.

Figure 4-1b
Change in OLF surface topography and unconsolidated thickness.

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4.2 Simulation Results - Closure Configurations

Results of model simulations are summarized in this section. Simulated groundwater depths below surface topography are plotted for each scenario to assess possible seep development. Plots of simulated water levels above the top of the weathered bedrock are used in the geotechnical slope stability analysis. Finally the change in water levels between different scenarios is shown to demonstrate the relative effects of each scenario's modification on the OLF hydrologic conditions.

4.2.1 Scenario 1 – No OLF Regrade

This scenario was simulated to assess hydrologic effects over the OLF area due to only IA reconfiguration. Figure 4-2 shows simulated average annual groundwater depths over the OLF area. A reduced model area was utilized to improve computational efficiencies. The range of simulated depths are similar to those calculated for current conditions and range from less than 3 feet in the west model area to more than 23 feet in the northern waste and south-central area. Average annual simulated saturated heights above weathered bedrock (Figure 4-3a) are similar to current conditions, but increase slightly in the western area (from <1 to 15 feet).

The change in groundwater levels from current conditions (Figure 4-3b), which reflects the relative effect of the IA reconfiguration, indicates levels increase less than a foot on average over the OLF. Locally, levels decrease less than 2.5 feet and increase up to 4 feet. The average increase is caused by a combination of factors, but is mostly due to removal of footing drains and removal of impervious areas.

4.2.2 Scenario 2 – OLF Regrade

A number of figures were generated to illustrate how the OLF area responds to the combination of IA closure (Scenario 1) and only a regrade in the OLF area. Simulated average annual depths for the OLF regrade show changes that mostly reflect the adjustment in unconsolidated material thicknesses (i.e., see Figure 4-1). As shown on Figure 4-4, depths increase in areas where the existing topographic surface is 'filled', while depths tend to decrease relative to the new surface topography, in areas where the existing surface is 'cut'. The range of depths is similar to that which develops in Scenario 1, and also do not indicate seep discharge, though levels are within 3 feet of surface.

An annual water balance evaluation of only the OLF waste extent (as shown on Figure 3-1), summarized on Figure 4-5) indicates that most precipitation

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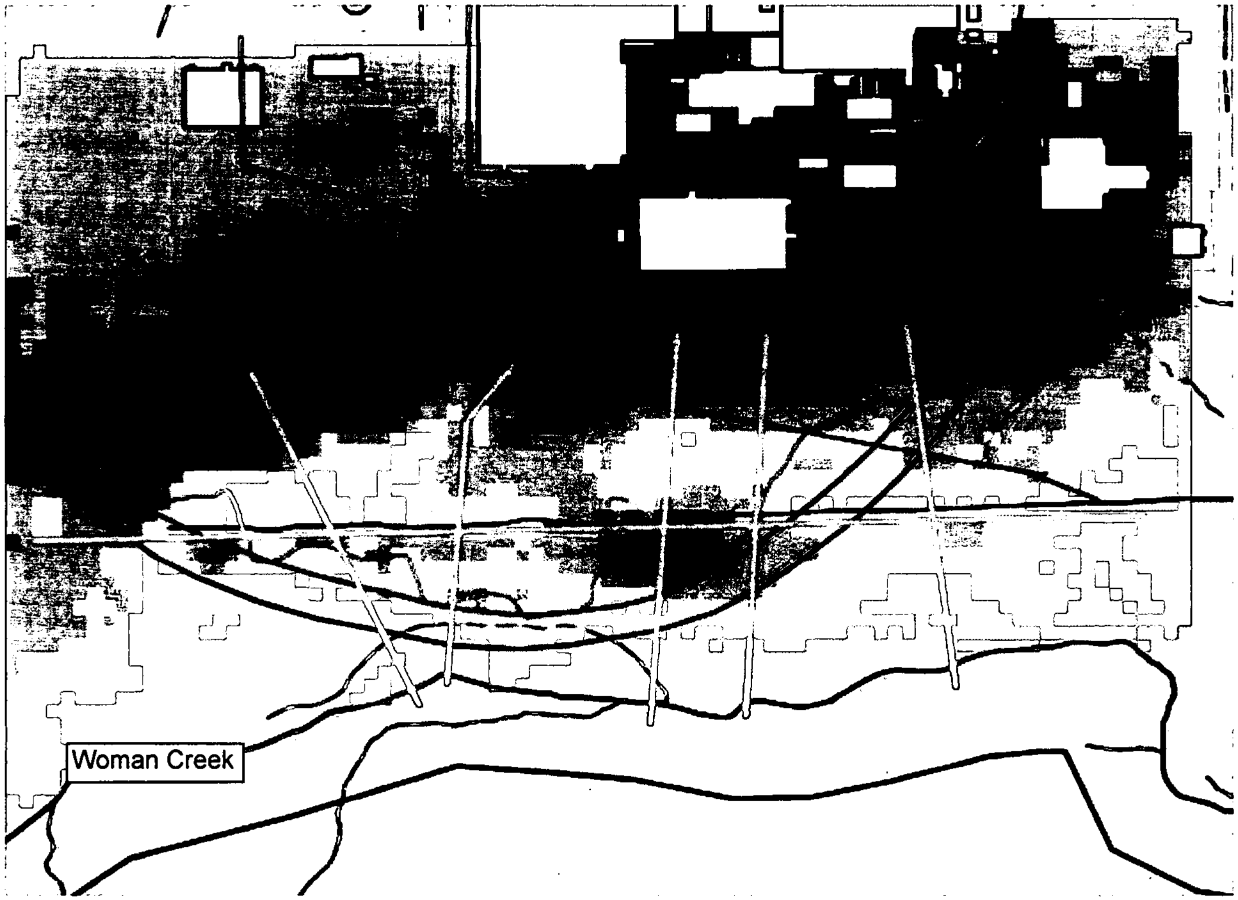

Simulated average annual groundwater depths (feet).

- -10 - 0
- 0 - 5
- 5 - 10
- 10 - 15
- 15 - 20
- 20 - 45

Note:

1) Scenario 1 assumes no modifications to the OLF, but IA is closed per site configuration.

2) Negative numbers (yellow) indicate groundwater levels are above ground surface. These areas represent seeps.

3) Scenario 1 assumes no modifications to the OLF.

Figure 4-2
Scenario 1 - Simulated (Typical Climate) average annual groundwater depths (ft)

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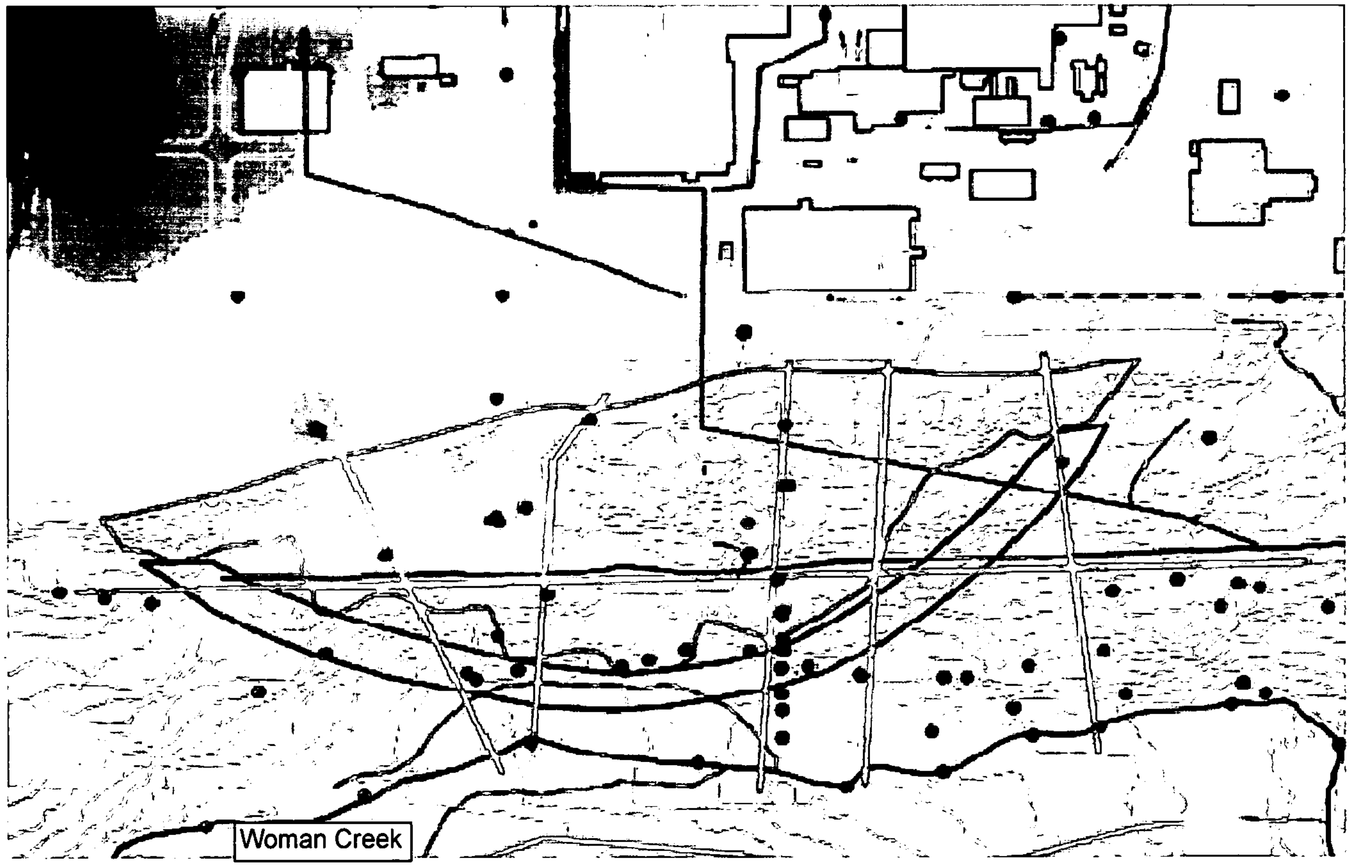
007



Simulated average annual groundwater height above weathered bedrock (feet).

- -15 - -10
- -10 - -5
- -5 - 0
- 0 - 5
- 5 - 10
- 10 - 15
- 15 - 20
- 20 - 40
- No Data

Note:

1) Negative numbers indicate areas where groundwater levels are below weathered bedrock.

2) Positive numbers indicate saturated groundwater heights above the top of the weathered bedrock surface.

3) Scenario 1 assumes no modifications to the OLF.

Figure 4-3a
Scenario 1 - Simulated (Typical Climate) average annual saturated height above Weathered Bedrock surface (ft).

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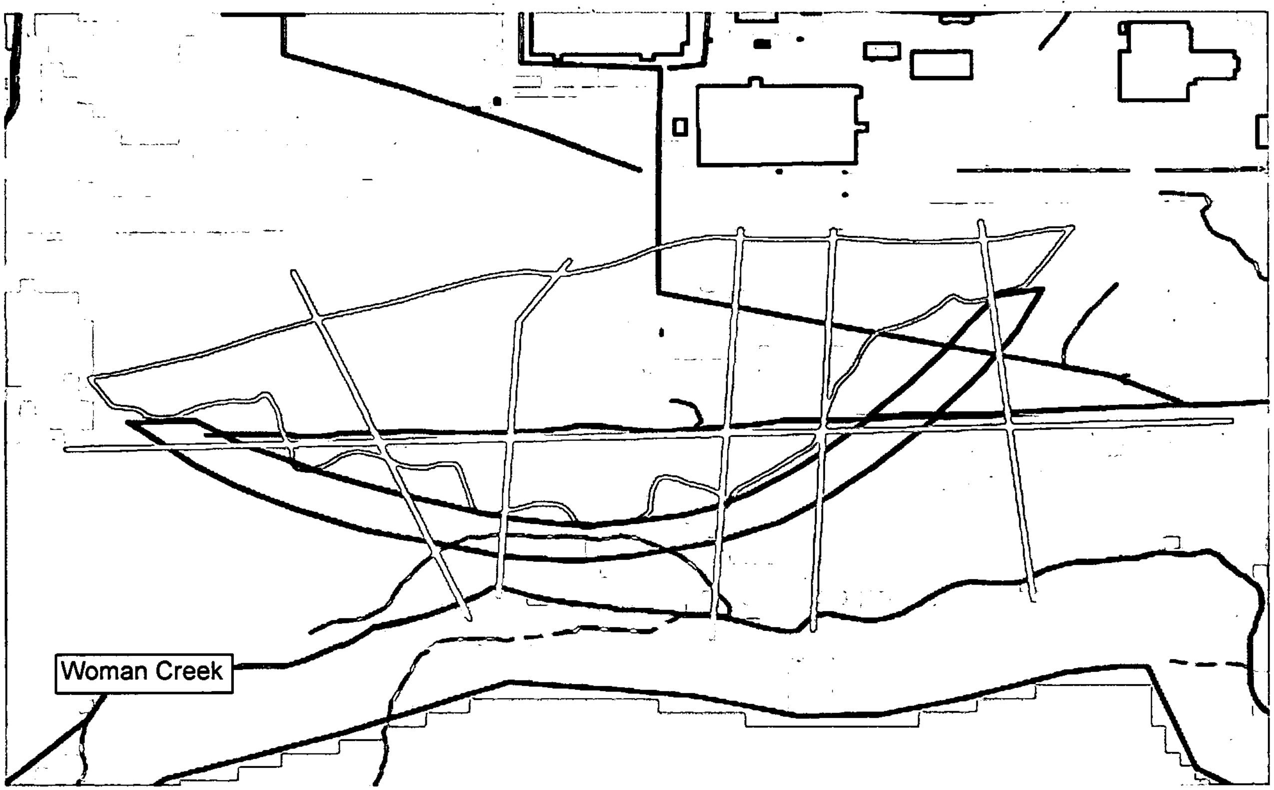

Change in groundwater levels (feet)

	-15 - -5
	-5 - -3
	-3 - -1
	-1 - 1
	1 - 3
	3 - 5
	5 - 15

Note:

1) Change in groundwater levels calculated by subtracting Scenario 1 simulated depths from current condition depths.

2) Negative numbers indicate areas where groundwater levels decrease from Calibration.

3) Positive numbers indicate saturated groundwater heights above the top of the weathered bedrock surface.

4) Change in levels south of Woman Creek invalid due to different model boundaries.

5) Scenario 1 assumes no modifications to the OLF.

Figure 4-3b
Scenario 1 change in groundwater levels (feet) from current conditions
(Effect of IA reconfiguration only)

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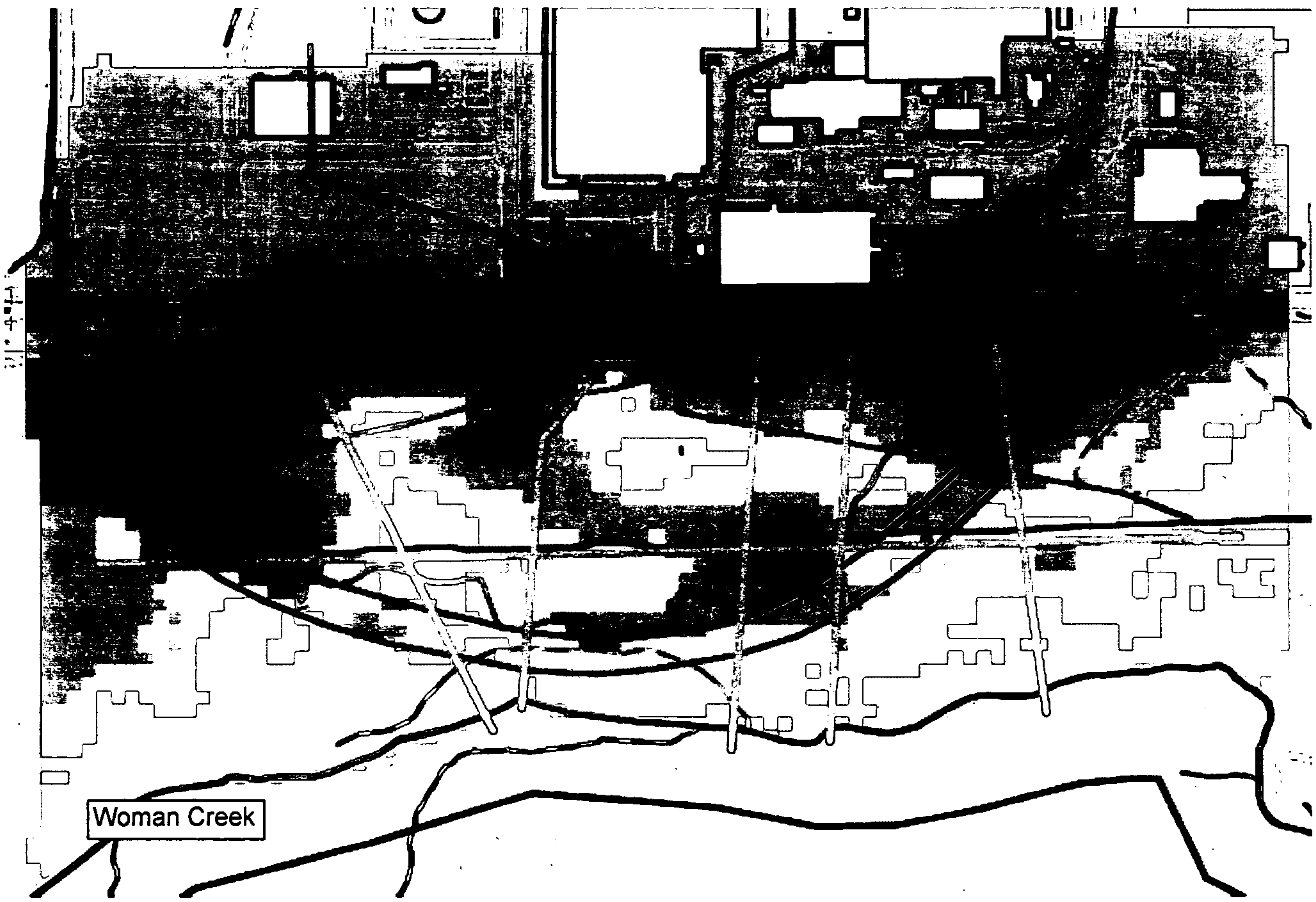

Simulated average annual groundwater depths (feet).

	-10 - 0
	0 - 5
	5 - 10
	10 - 15
	15 - 20
	20 - 45

Note:

1) Scenario 2 assumes IA closure and only a regrade over the OLF.

2) Negative numbers (yellow) indicate groundwater levels are above ground surface. These areas represent seeps.

Figure 4-4

Scenario 2 - Simulated (Typical Climate) average annual groundwater depths (ft)

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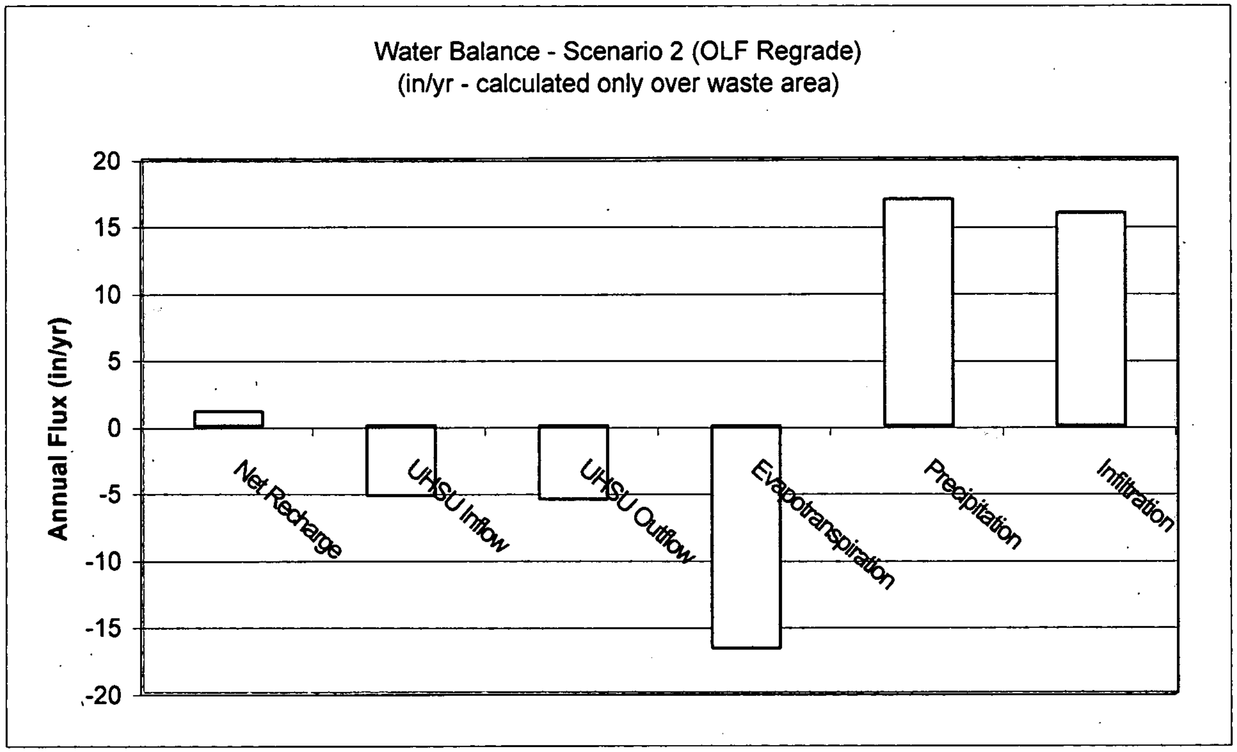

NOTE:
Infiltration differs from Net recharge because it is calculated as infiltration at ground surface only. Lateral UHSU inflow and outflows is calculated for waste, underlying colluvium, and weathered bedrock. Highest lateral flows are through the coluvium. Net recharge is calculated as net flux across water table and includes evapotranspiration loss through the unsaturated zone (Actual recharge is much higher).

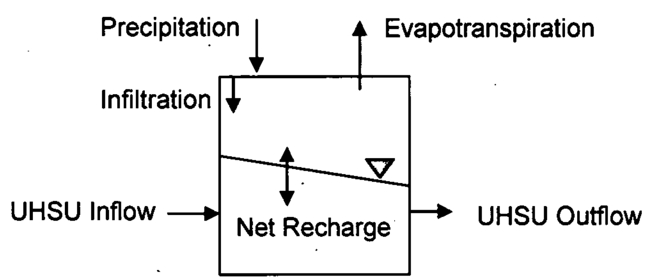

Figure 4-5
Scenario 2 -
Simulated water balance for waste area (in/yr)

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infiltrates due to relatively high surface soil permeabilities. Of this infiltration, most is lost via evapotranspiration through the root zone. A smaller, but important portion of this infiltration recharges the groundwater flow system. Although net annual recharge is less than annual lateral inflow or outflow (through the entire UHSU, including weathered bedrock and underlying Colluvium), it includes annual discharge to evapotranspiration via the unsaturated zone. Local recharge and evapotranspiration account for most of the groundwater level seasonal variability and changes in groundwater storage with time, rather than lateral flow variations.

In Figure 4-6 the average annual saturated height above weathered bedrock increases in the north-western part of the OLF and less notably in the east-central area (previously levels below top of bedrock) compared to Scenario 1.

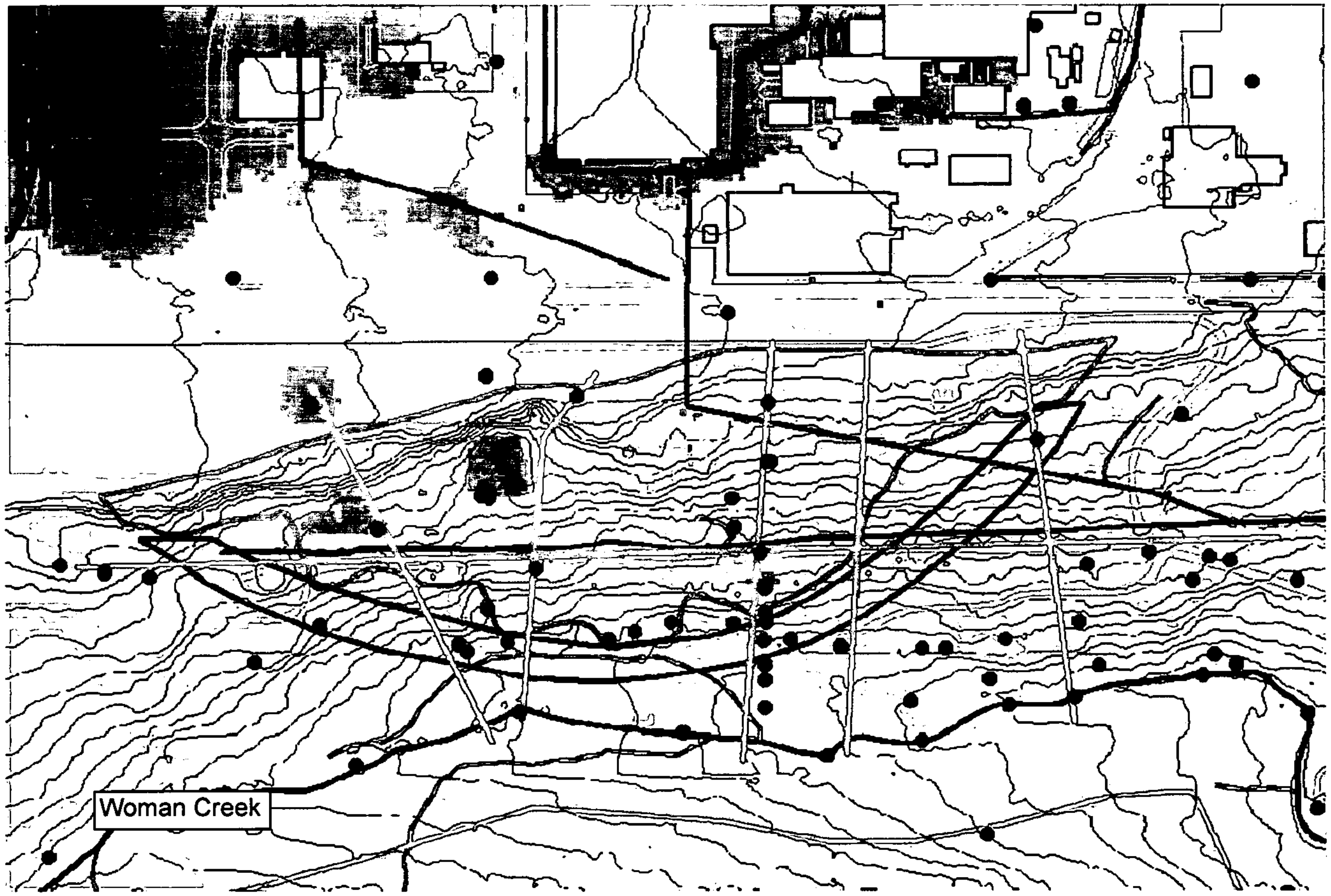
As a conservative estimate of high water levels within the OLF area, a 100-year basis wet-year climate was simulated for Scenario 2. Results shown on Figure 4-7 indicate groundwater discharges to surface in the south-eastern and central areas of the OLF. This condition represents the wettest part of the wet-year climate sequence. Although not shown, it may also be possible for localized groundwater levels to reach ground surface in Scenario 2 during high recharge periods. For the wet climate, saturated heights above the weathered bedrock (Figure 4-8) increase above the typical climate, ranging from 5 to 15 feet over most of the OLF, but in localized areas it exceeds 20 feet. Average annual wet-year groundwater levels increase an average of about 1.3 feet over the waste area. Compared to average annual levels for a typical climate year, the highest wet-year levels increase from about 2 feet within the waste area to more than 4 feet south of the waste area.

Figure 4-9 illustrates changes in water table elevation from Scenario 1. Results indicate levels increase within most of the OLF 3 to 7 feet. This increase in elevation also appears to cause an increase north of the OLF in the B440/B444 area. Levels appear to decline up to 3 feet immediately south of the waste extent.

4.2.3 Scenario 3 – OLF Regrade, Buttress fill, and Buttress drain

A buttress fill and upgradient buttress drain are simulated in Scenario 3 at the southern end of the waste area (see Figure 3-1). The buttress fill is assumed to extend to the top of the weathered bedrock and is assigned a very low hydraulic conductivity (1e-10 m/s). It is represented in the model as using cells wide as indicated by the boundary shown on Figure 3-1. The buttress drain is also assumed to extent to the top of the weathered bedrock. In the model, a low resistance drain is simulated by assigning a high conductance to the drain cells.

604



Simulated average annual groundwater height above weathered bedrock (feet).

-15 - -10	
-10 - -5	
-5 - 0	
0 - 5	
5 - 10	
10 - 15	
15 - 20	
20 - 40	
No Data	

Note:

1) Scenario 2 assumes the OLF is regraded along with the IA. No other modifications in the OLF assumed.

2) Negative numbers indicate areas where groundwater levels are below weathered bedrock.

3) Positive numbers indicate saturated groundwater heights above the top of the weathered bedrock surface.

Figure 4-6

Scenario 2 - Simulated (Typical Climate) average annual saturated height above Weathered Bedrock surface (ft)

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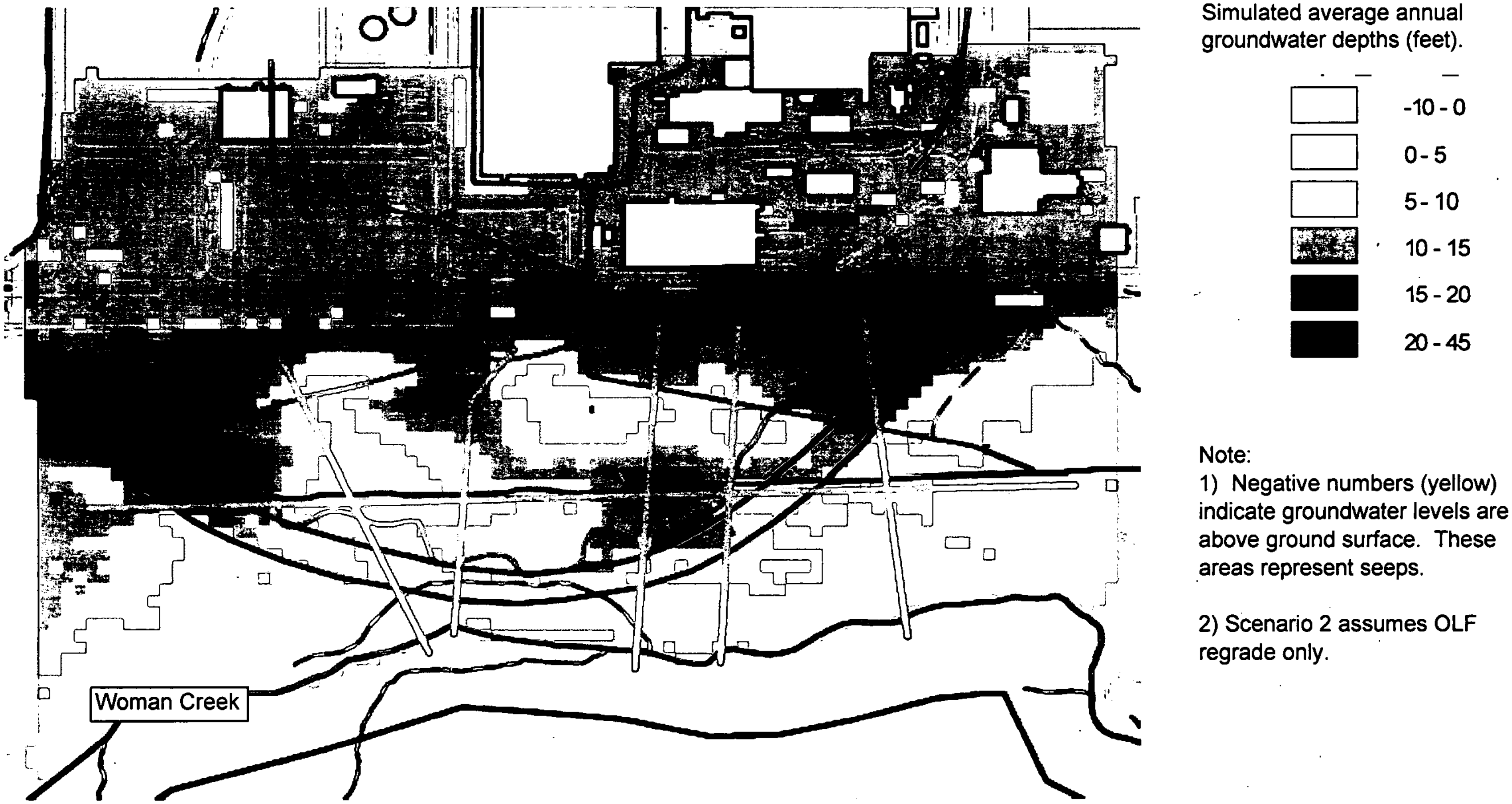

Figure 4-7
Scenario 2 - Simulated (Wet-Year Climate) minimum annual groundwater depths (ft)

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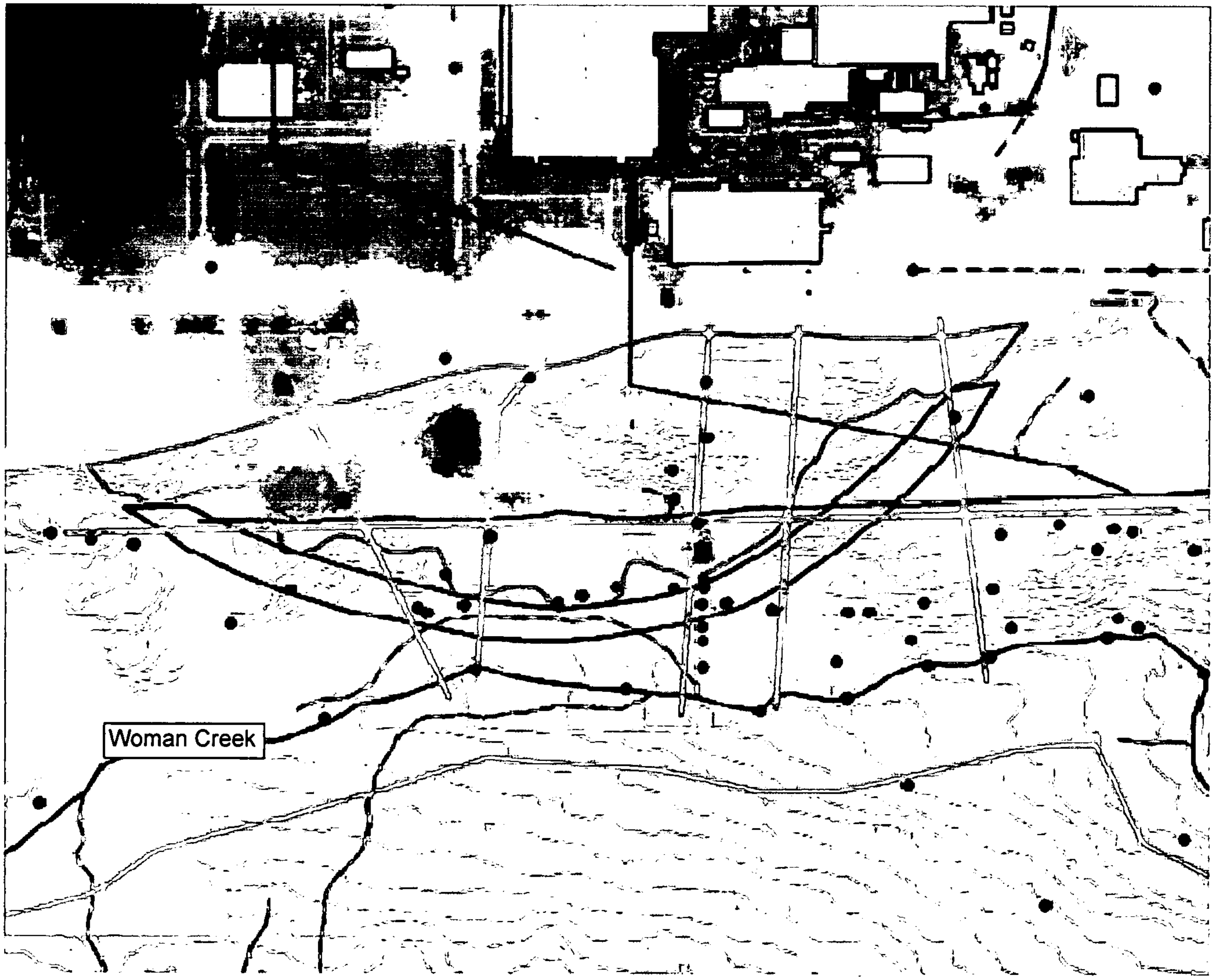

Simulated average annual groundwater height above weathered bedrock (feet).

	-15 - -10
	-10 - -5
	-5 - 0
	0 - 5
	5 - 10
	10 - 15
	15 - 20
	20 - 40
	No Data

Note:

1) Negative numbers indicate areas where groundwater levels are below weathered bedrock.

2) Positive numbers indicate saturated groundwater heights above the top of the weathered bedrock surface.

3) Scenario 2 assumes OLF regrade only.

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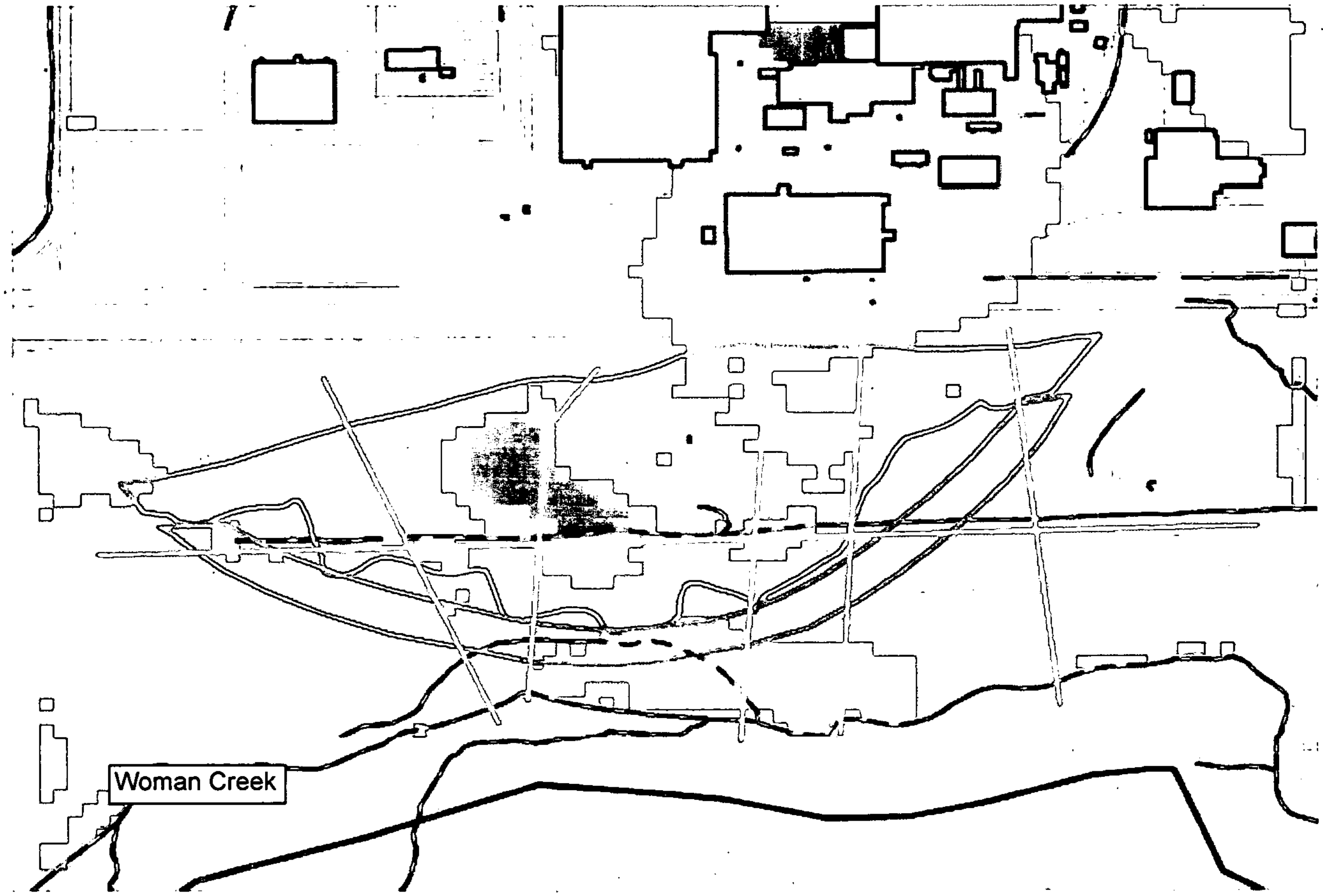
Figure 4-8
Scenario 2 - Simulated (Wet-Year Climate) maximum annual saturated height above Weathered Bedrock surface (ft)

809



Change in groundwater levels (feet)

■	-15 - -5
□	-5 - -3
□	-3 - -1
□	-1 - 1
□	1 - 3
□	3 - 5
■	5 - 15

Note:

1) Change in groundwater levels calculated by subtracting Scenario 1 depths from Scenario 2.

2) Negative numbers indicate areas where groundwater levels decrease from Scenario 1.

3) Positive numbers indicate saturated groundwater heights above the top of the weathered bedrock surface.

4) Scenario 2 assumes OLF regrade only.

Figure 4-9
Scenario 2 change in groundwater levels (ft) from Scenario 1
(Effect of regrade only - Typical climate sequence)

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Simulated groundwater depths and saturated heights above the weathered bedrock (Figures 4-10 and 4-11, respectively) are similar those generated in Scenario 2, but decline due to the buttress drain upgradient of the buttress fill. Compared to Scenario 2, levels decrease up to about 3 feet for the lower half of the OLF extent and decrease up to about 7 feet near the buttress drain upgradient of the buttress, as shown on Figure 4-12.

4.2.4 Scenario 4 – OLF Regrade, Buttress fill, Buttress drain, and Slurry Wall

The effect of adding a slurry wall to the last scenario with a regrade, buttress fill and buttress drain is described here. The slurry wall, placed immediately north of the waste extent in the integrated model, is assigned a very low hydraulic conductivity (1e-10 m/s), similar to the buttress fill. The water balance performed on Scenario 2 indicates that most of the lateral inflow occurs in the unconsolidated material of the UHSU. Therefore, extending the slurry wall from ground surface to the top of the weathered bedrock will block most of the lateral inflow to the OLF from upgradient.

Simulated average annual groundwater depths, shown on Figure 4-13 are similar to Scenario 3. Only a slight adjustment to the average annual saturated height above the weathered bedrock is simulated (Figure 4-14). This is further indicated on Figure 4-15, showing the change in groundwater levels compared to Scenario 3. Results show that levels immediately upgradient of the slurry wall increase less than 3 feet, while those immediately downgradient, within the waste area, decrease less than 3 feet. The change in levels is constrained to about 200 to 300 feet on either side of the slurry wall. Based on this simulation and the lower weathered bedrock permeabilities, additional declines in the water table are unlikely if the slurry wall were extended through the weathered bedrock.

5.0 Fate and Transport of VOCs in the OLF area

5.1 Model Development

The fate and transport of VOCs detected in the OLF area are evaluated for closure Scenarios 2 and 3. These two scenarios are selected for fate and transport simulations because they represent configurations with the greatest potential for producing higher downgradient VOC concentrations. Specifically, impacts to surface water (Woman Creek, or seeps) are assessed. Available groundwater sampling data indicate elevated concentrations of Tetrachloroethylene (PCE) were detected in the central portion of the OLF waste area.

The approach used to model the fate and transport of PCE (and its daughter products) from the waste area is consistent with that described in detail in the IA VOC fate and transport modeling study (KH, 2004). The RT3D code is used to

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Simulated average annual groundwater depths (feet).

	-10 - 0
	0 - 5
	5 - 10
	10 - 15
	15 - 20
	20 - 45

Note:

1) Scenario 3 assumes OLF regrade, clay buttress and toe drain on upgradient side of buttress.

2) Negative numbers (yellow) indicate groundwater levels are above ground surface. These areas represent seeps.

3) Scenario 3 includes OLF regrade, Buttress fill and drain.

Figure 4-10
Scenario 3 – Simulated (Typical Climate) average annual groundwater depths (ft)

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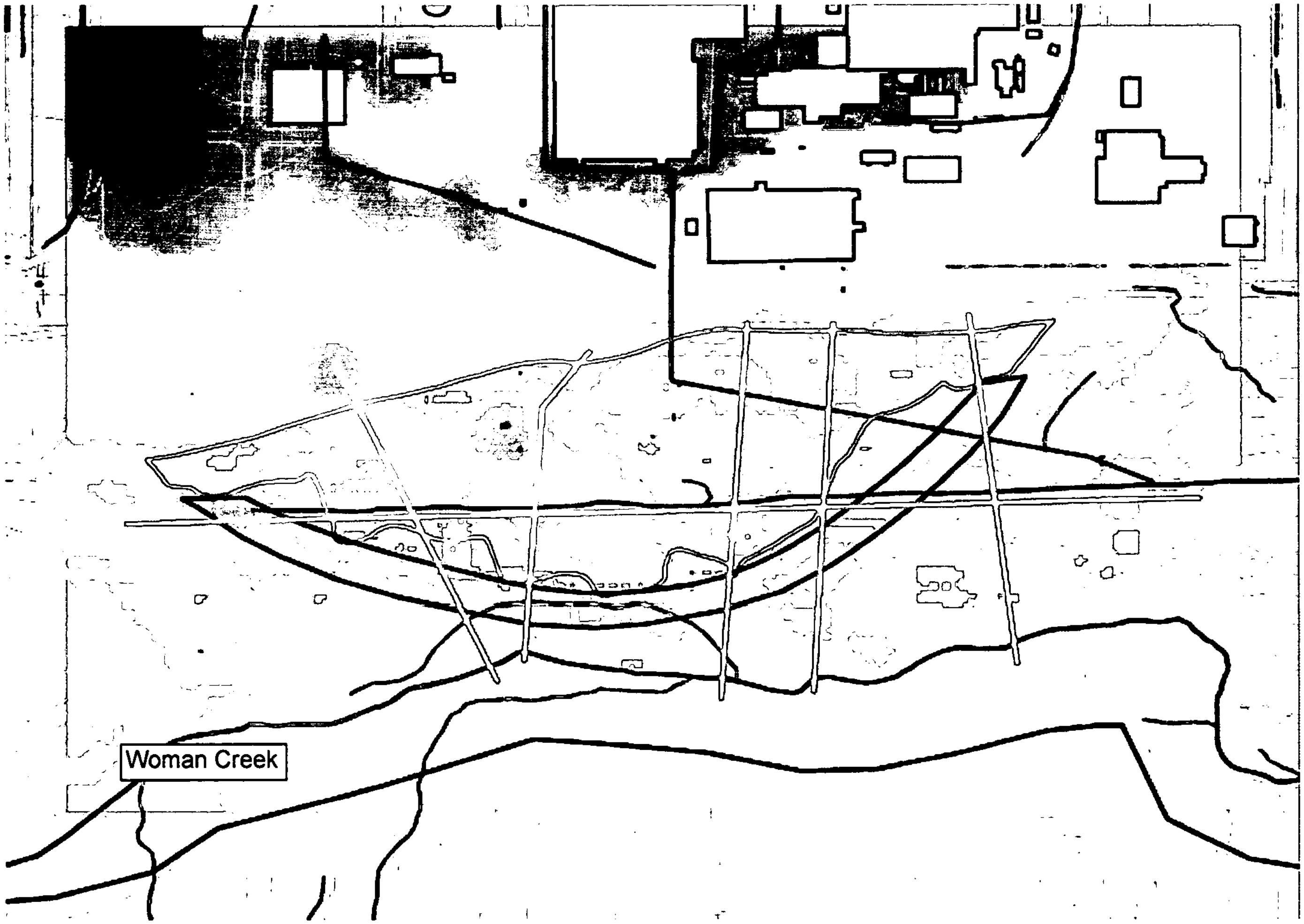

Figure 4-11
Scenario 3 – Simulated (Typical Climate) average annual saturated height above Weathered Bedrock surface (ft).

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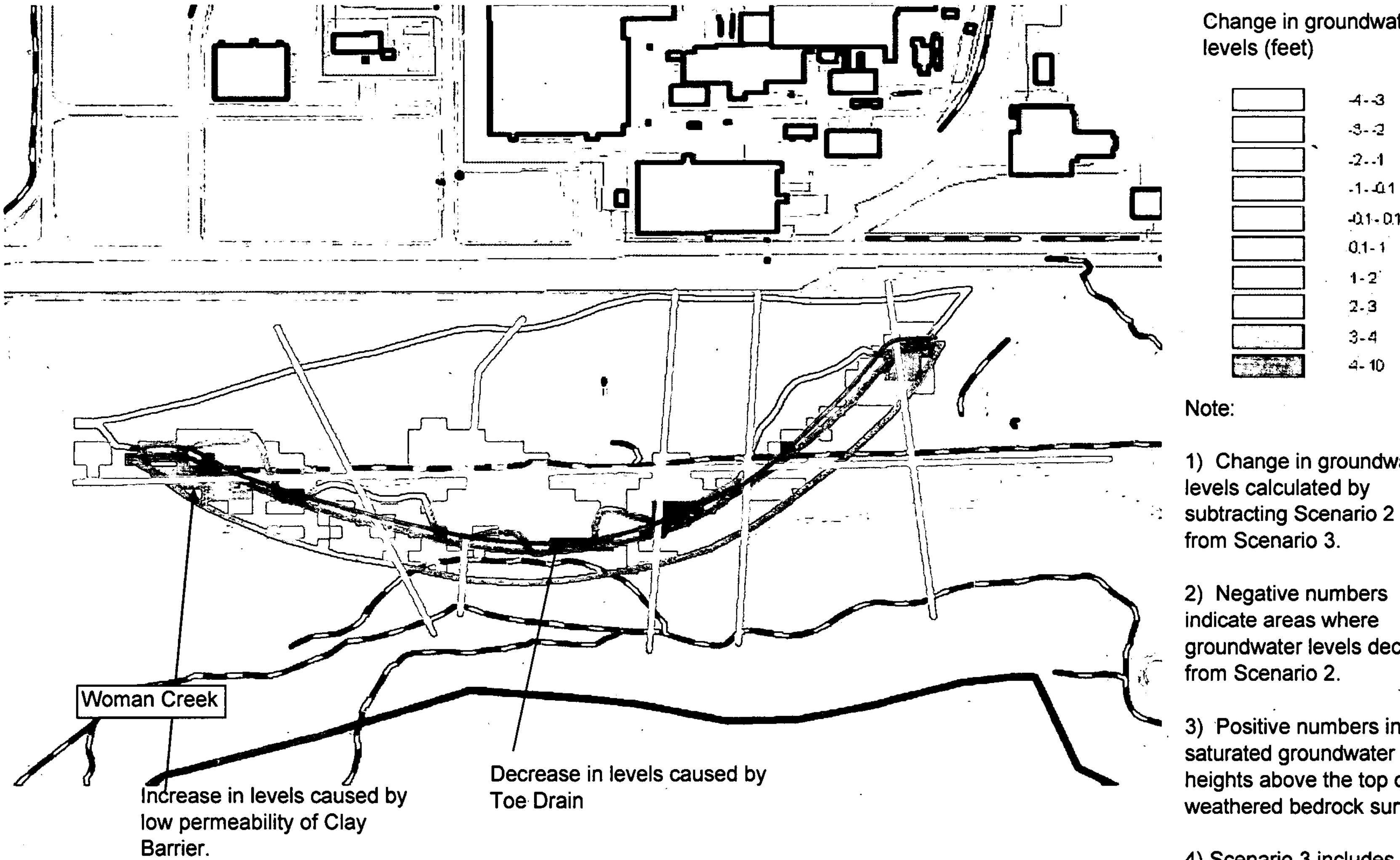

Note:

1) Change in groundwater levels calculated by subtracting Scenario 2 depths from Scenario 3.

2) Negative numbers indicate areas where groundwater levels decrease from Scenario 2.

3) Positive numbers indicate saturated groundwater heights above the top of the weathered bedrock surface.

4) Scenario 3 includes OLF regrade, Buttress fill and drain.

Figure 4-12
Scenario 3 change in groundwater levels (feet) from Scenario 2
(Effect of adding clay buttress and toe drain to regrade)

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Simulated average annual groundwater depths (feet).

	-10 - 0
	0 - 5
	5 - 10
	10 - 15
	15 - 20
	20 - 45

Note:

1) Scenario 4 assumes OLF regrade, clay buttress, toe drain on upgradient side of buttress, and slurry wall (see Figure 3-1 for locations of these features).

2) Negative numbers (yellow) indicate groundwater levels are above ground surface. These areas represent seeps.

3) Scenario 4 includes OLF regrade, Buttress fill, drain and upgradient slurry wall.

Figure 4-13
Scenario 4 – Simulated (Typical Climate) average annual groundwater depths (ft)

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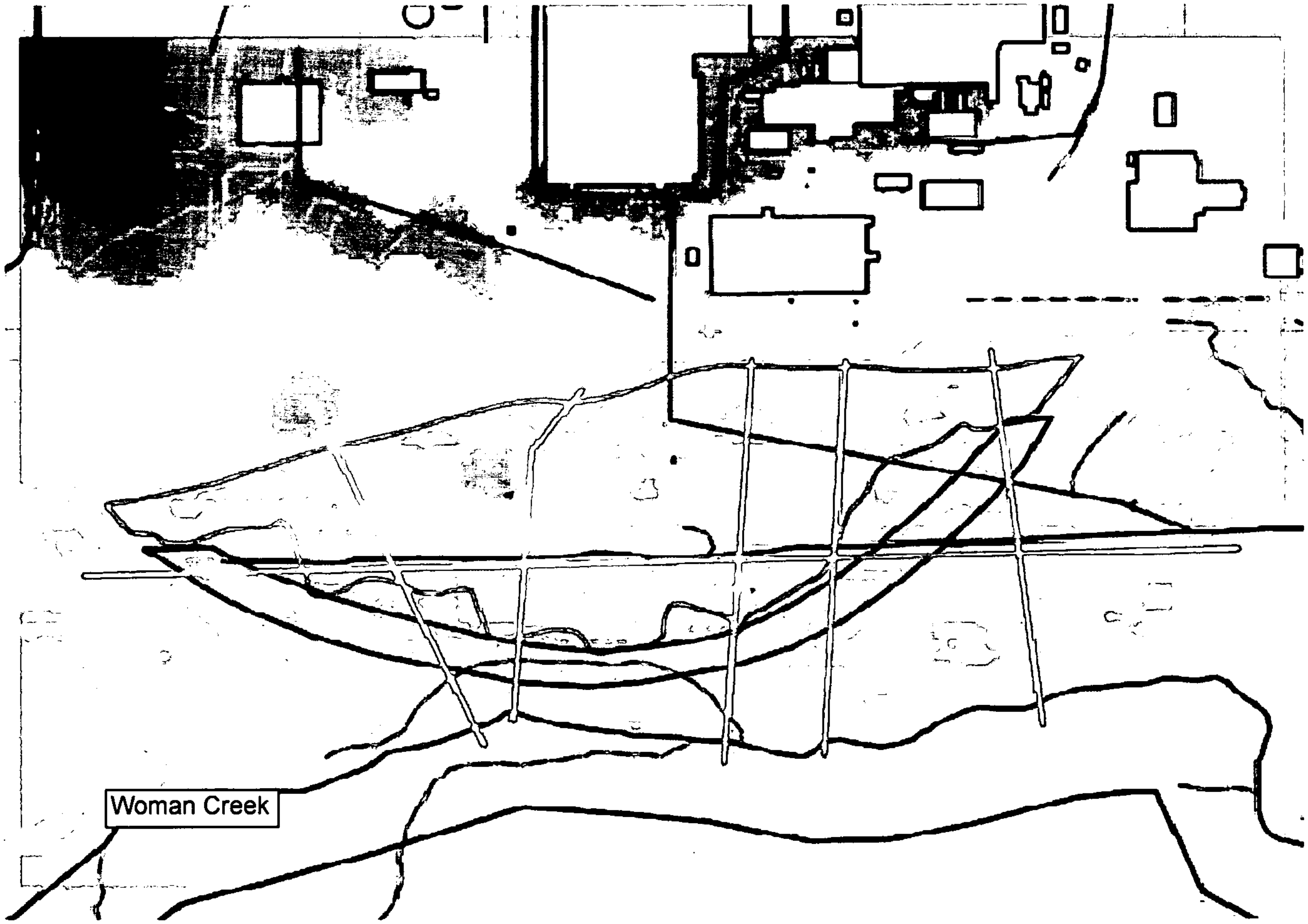

Simulated average annual groundwater height above weathered bedrock (feet).

	-15 - -10
	-10 - -5
	-5 - 0
	0 - 5
	5 - 10
	10 - 15
	15 - 20
	20 - 40
	No Data

Note:

1) Negative numbers indicate areas where groundwater levels are below weathered bedrock.

2) Positive numbers indicate saturated groundwater heights above the top of the weathered bedrock surface.

3) Scenario 4 includes OLF regrade, Buttress fill, drain and upgradient slurry wall.

Figure 4-14

Scenario 4 – Simulated (Typical Climate) average annual saturated height above Weathered Bedrock surface (ft).

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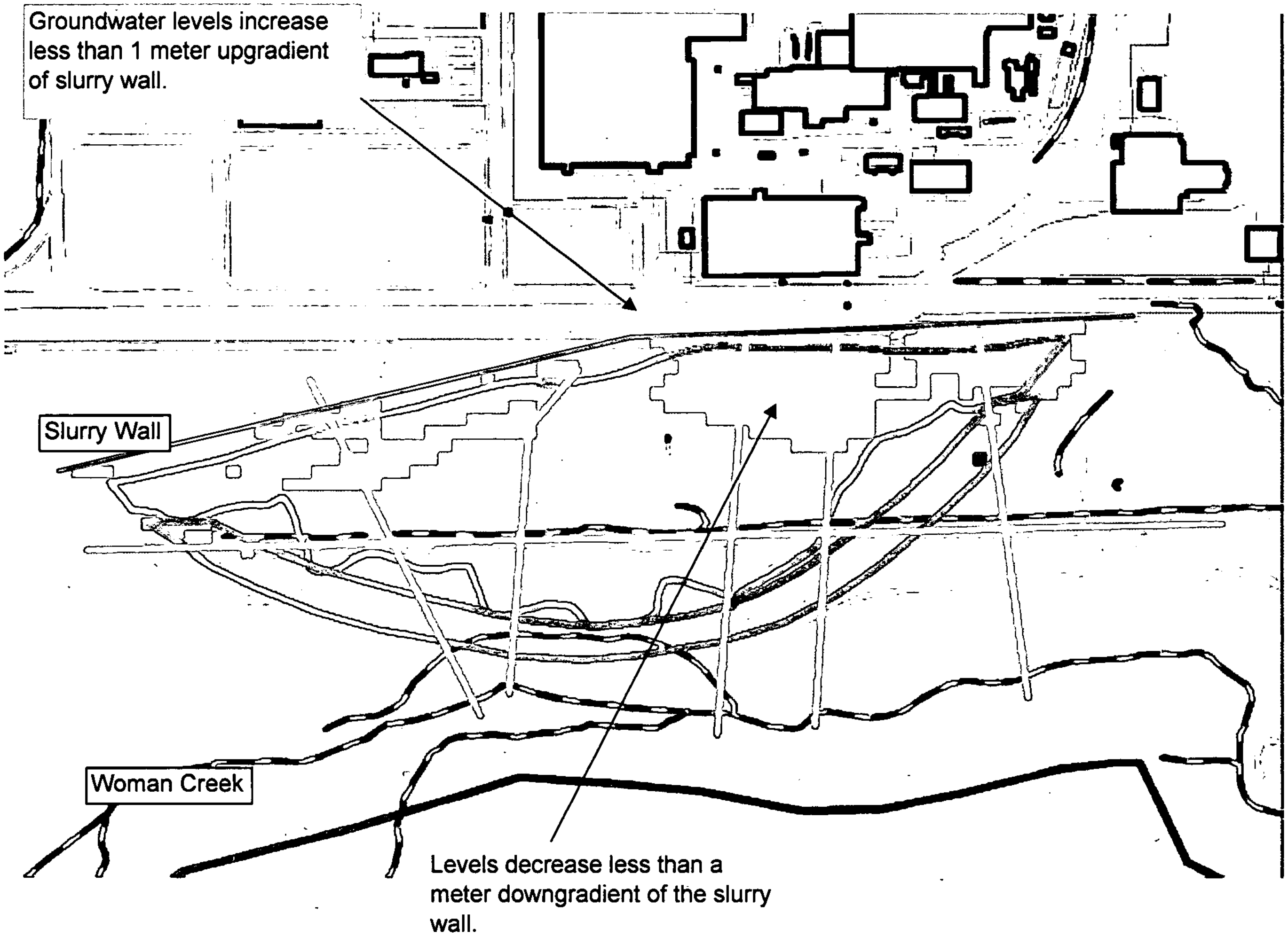

Change in groundwater levels (feet)

■	-15 - -5
□	-5 - -3
□	-3 - -1
□	-1 - 1
□	1 - 3
□	3 - 5
■	5 - 15

Note:

1) Change in groundwater levels calculated by subtracting Scenario 3 depths from Scenario 4.

2) Negative numbers indicate areas where groundwater levels decrease from Scenario 2.

3) Positive numbers indicate saturated groundwater heights above the top of the weathered bedrock surface.

4) Scenario 4 includes OLF regrade, Buttress fill, drain and upgradient slurry wall.

Figure 4-15
Scenario 4 change in groundwater levels (feet) from Scenario 3
(Effect of adding a slurry wall)

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model the fate and transport of PCE so that advection and attenuation processes including degradation, sorption, diffusion and dispersion could be considered.

Three-dimensional time-averaged water levels (WY2000), estimated using the integrated flow model for Scenarios 2 and 3, are first used to define approximate steady-state velocity fields for the RT3D simulations. A number of conservative fate and transport simulations are then conducted to estimate a range of long-term groundwater concentrations at surface water discharge locations given uncertainties in source location, depth and timing, among other parameters controlling fate/transport. Source locations simulated in the model are based on inferred locations (shown on Figure 5-1) and long-term concentrations are assumed constant. This assumption is reasonable because concentrations at wells in the OLF show no clear increasing, or decreasing trends in time.

The following long-term simulations were conducted for Scenarios 2 and 3:

- Scenario 1 - Basecase;
- Scenario 2 - Low degradation (one tenth of basecase);
- Scenario 3 - Low porosity (halved for all layers);
- Scenario 4 - Low degradation and increase in hydraulic conductivity (one tenth and three times for all layers, respectively);
- Scenario 5 - Advection-dispersion only (no sorption, degradation, or ET loss), increase in hydraulic conductivity (2 times all layers); and
- Scenario 6 - Advection=dispersion only.
- Fate and Transport Simulation Results

Results from both simulations show that neither PCE, nor its daughter products, reach Woman Creek at concentrations above surface water action concentrations for any of the conservative simulations considered. Results are summarized on Figures 5-2 and 5-3, for scenarios 2 and 3, respectively. For scenario 3, with the buttress fill and buttress drain, more conservative simulations indicate it is possible for concentrations to reach the drain, but they are likely to be lower than the surface water action levels.

6.0 Summary and Conclusions

This summary presents modeling the integrated hydrologic response of current conditions and four different OLF closure configuration scenarios, and the fate and transport from inferred source areas. Several steps were required. First, all available data, including recent water levels and geotechnical information, were compiled into a GIS and analyzed. A localized, fully-integrated flow model was then developed for the OLF area based on these data for current conditions. Model performance runs were simulated to demonstrate that parameter values were appropriate for simulating closure configurations. Next, the integrated model was modified to simulate the four closure configurations to show the

616

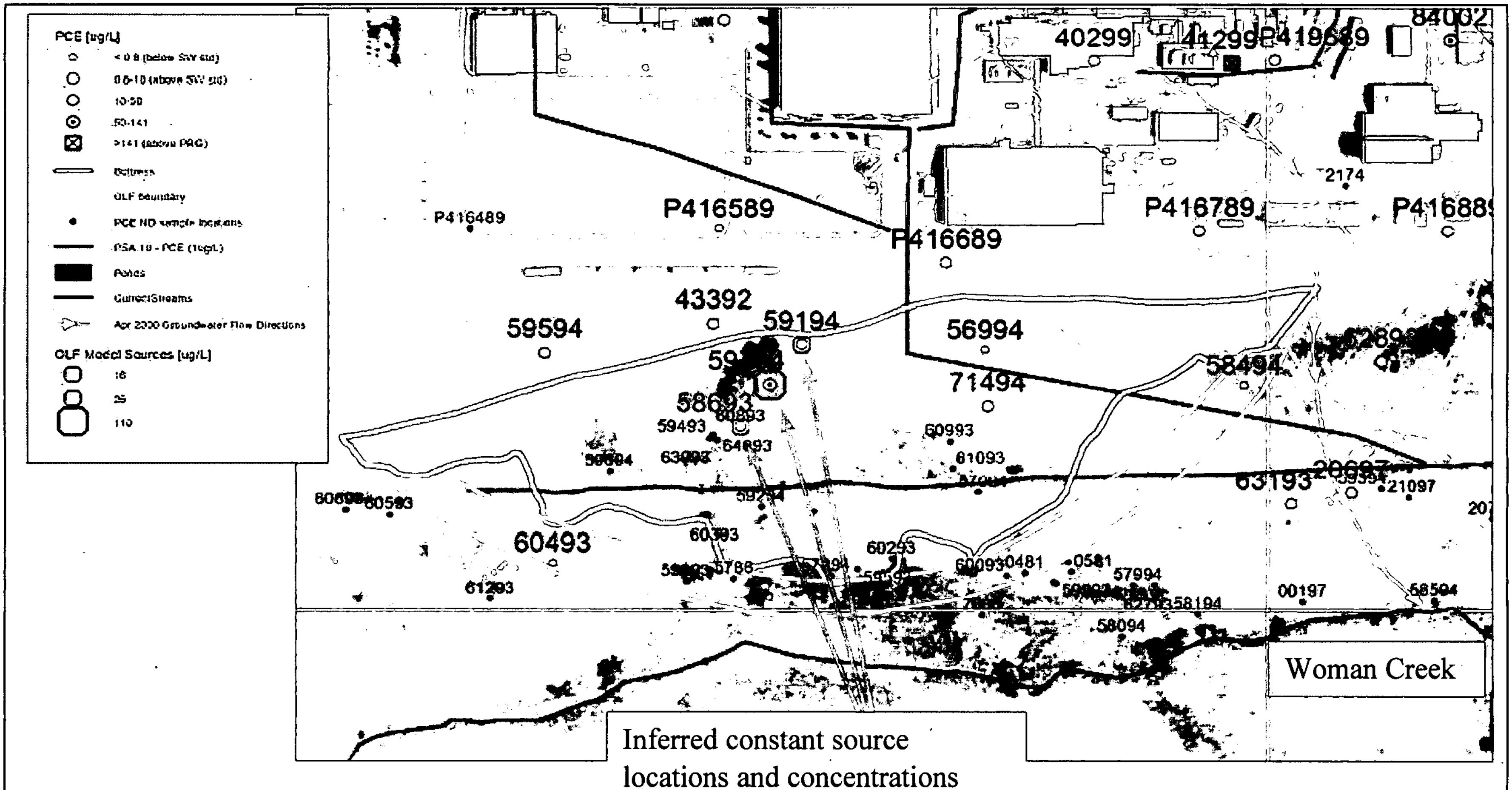

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Figure 5-1
Inferred location of VOC sources in the OLF area

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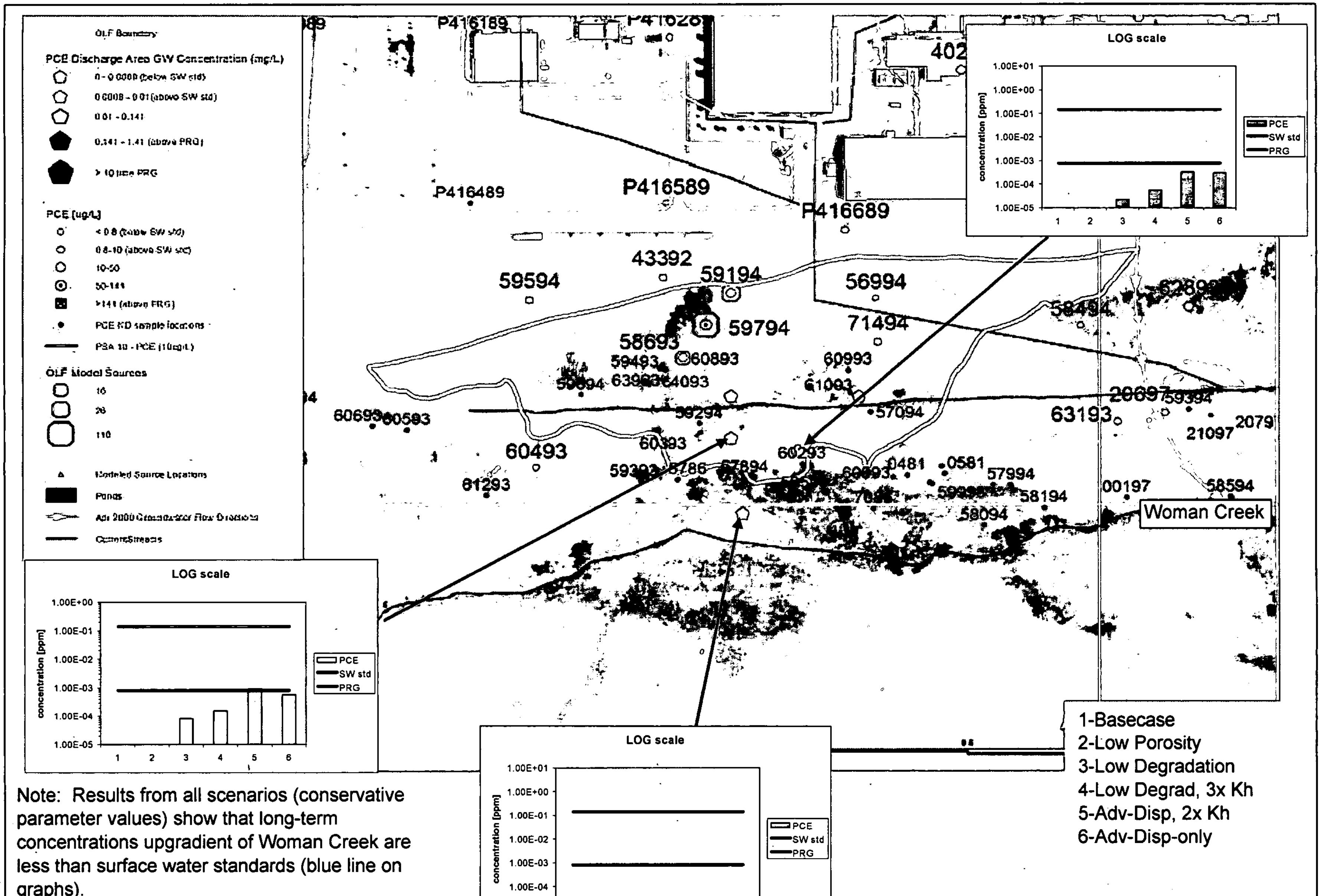
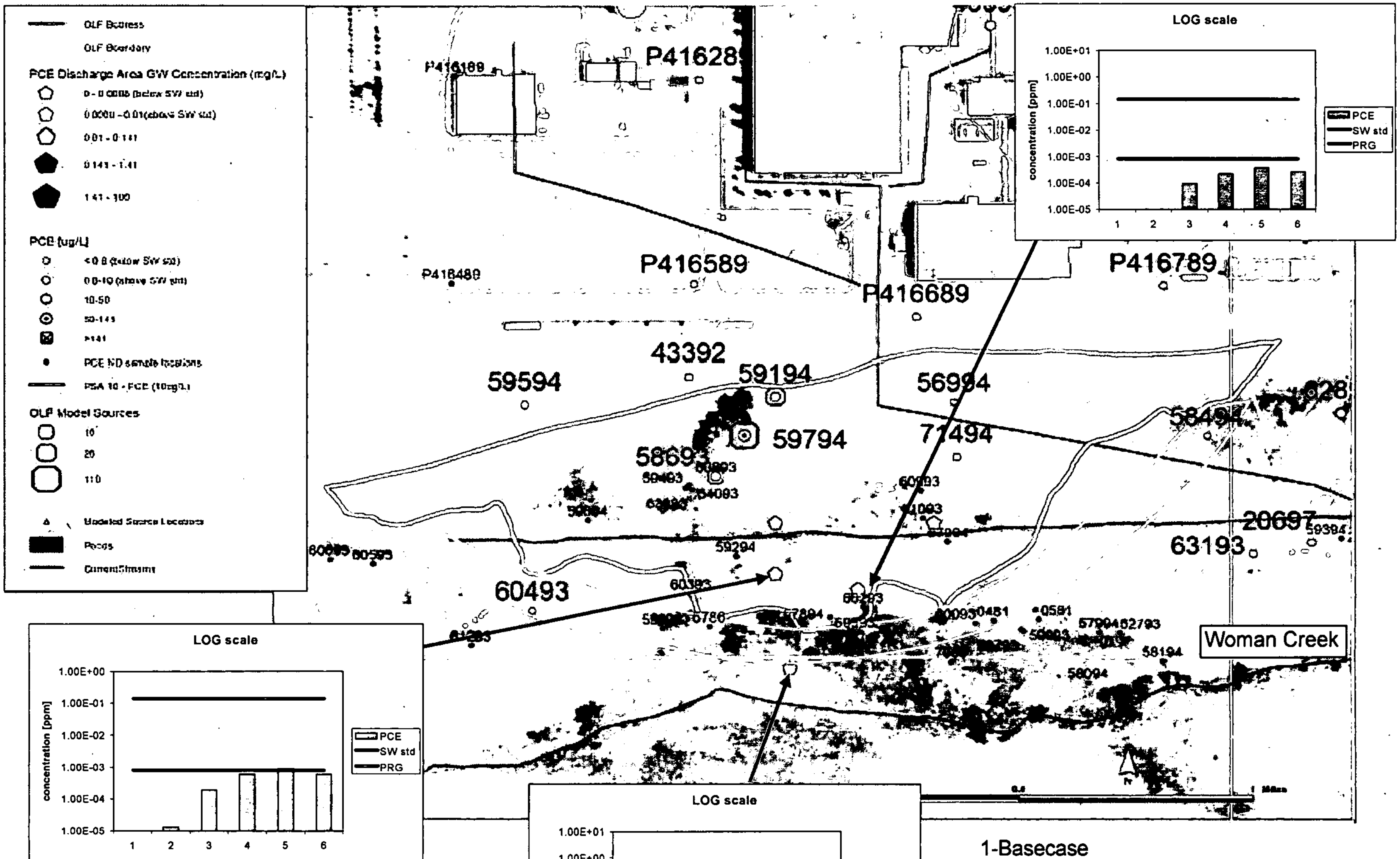
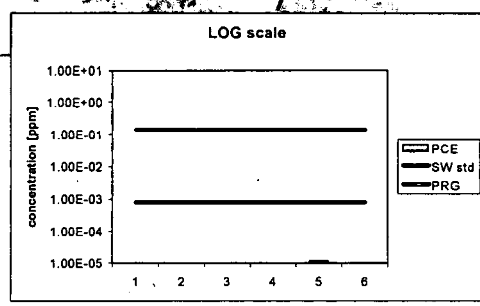


Figure 5-2
Fate and Transport Results – Scenario 2





Note: Results from all scenarios (conservative parameter values) show that concentrations are less than surface water standards (blue line on graphs) near toe drain.

1-Basecase
2-Low Porosity
3-Low Degradation
4-Low Degrad, 3x Kh
5-Adv-Disp, 2x Kh
6-Adv-Disp-only

Figure 5-3
Fate and Transport Results – Scenario 3

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relative effects of each scenario. A 100-year wet-climate sequence was simulated in the basecase, OLF regrade scenario to approximate the highest groundwater levels in the OLF area. Finally, the fate and transport of elevated levels of PCE within the OLF was evaluated using the reactive transport code, RT3D, for two closure configurations.

The four OLF closure configurations considered in the integrated flow model include the following:

- Scenario 1 - IA reconfiguration, no OLF modifications;
- Scenario 2 - IA reconfiguration, OLF regrade (basecase);
- Scenario 3 - IA reconfiguration, OLF regrade, buttress fill, and buttress drain; and
- Scenario 4 - IA reconfiguration, OLF regrade, buttress fill, buttress drain, and slurry wall.

Several conclusions can be made from the integrated OLF flow model simulations and VOC fate and transport modeling. These are summarized below:

1) A combination of natural and anthropogenic factors affects local groundwater levels within the OLF area in the current (pre-closure) configuration. These include the following:
    1) Anthropogenic factors:
        1) Drains north of OLF in IA;
        2) Utility corridors in IA;
        3) Leaky water supply lines (Bldg 124 area); and
        4) Pavement and buildings.
    2) Natural factors:
        1) Hillslope configuration:
            1) Weathered bedrock surface;
            2) Unconsolidated thickness spatial distribution; and
            3) Vegetation distribution/types.
        2) Climate sequence characteristics; and
        3) Unsaturated and saturated zone hydraulic properties of waste and surrounding media.
2) Historical time-average groundwater levels in the OLF area indicate saturated heights above the weathered bedrock range from 0 to 10 feet over about two thirds of the waste extent, while the levels are actually below the bedrock over the remaining one third.
3) For current conditions, average annual observed groundwater depths throughout the OLF area vary from over 20 feet depth at the top of the

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hillslope to less than 3 feet near Woman Creek and in shallow bedrock areas within the OLF.

4) Model results show that reconfiguring the IA (Scenario 1) causes groundwater levels to increase less than one foot over the OLF. However locally, levels decrease less than 3 feet and increase up to 4 feet. Simulated depths are similar to current conditions and range from less than 5 feet to over 20 feet within the OLF.

5) Simulated effects of regrading the OLF and reconfiguring the IA (Scenario 2) for a typical climate sequence (WY2000) cause levels to increase an average of about two feet. Locally they decrease up to 3.5 feet and increase up to nearly 7 feet. Simulated groundwater depths vary throughout the OLF, mostly in response to 'fill' and 'cut' adjustments. At the western and eastern waste extents depths increase to near 40 feet due to increased fill thickness. Saturated heights above the bedrock increase from 3 to 7 feet over most of the OLF compared to Scenario 1.

6) Simulating a wet-year climate (100-year basis) sequence for Scenario 2 causes average OLF groundwater levels to increase about two feet (ranging from 0 to 4 feet) compared to a typical climate sequence. Results also indicate that groundwater reaches ground surface in shallow bedrock areas, though this could be controlled by increasing the regrade surface height above bedrock. These simulated groundwater levels represent conservatively high levels that might be sustained for up to a month during a wet year climate sequence.

7) Simulated effects of adding a buttress fill and upgradient buttress drain (Scenario 3) cause average annual groundwater levels to decrease less than one foot over the OLF. However locally, the drain causes levels to decrease up to 3 feet over the southern half of the OLF. Levels near the drain decrease about 11 feet. Simulated annual discharge rates from the drain are less than 1 gpm.

8) Simulated effects of adding a slurry wall to Scenario 3 (Scenario 4) cause average annual groundwater levels over the OLF to change less than one foot. However levels downgradient (south) of the slurry wall decrease less than 3 feet, while those upgradient of the slurry wall (north) increase up to 3 feet within about 300 feet.

9) Results of the current and closure simulations conducted in this study indicate that surface regrading results in the largest impact on OLF groundwater levels. Modeling also shows that seeps may occur under wetter climate though this could be controlled by adjusting the surface regrade topography.

10) Reactive fate and transport modeling of PCE (and daughter products) detected in groundwater in the OLF waste indicate that concentrations at

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Woman Creek remain well below surface water standards for both Scenario 1 and 3. More conservative fate and transport scenarios (most conservative parameter values) show that groundwater concentrations may reach the buttress drain at detectable concentrations, though they remain below the surface water standards. Results of the fate and transport simulations assume that the PCE source concentrations remain constant during any regrade of the area.

11)A sensitivity analysis to determine the most sensitive parameters controlling water levels in the OLF was not conducted in this study, though results suggest that the regrade surface, bedrock depth and waste area hydraulic properties are the most sensitive. An uncertainty analysis to assess the range of hydrologic response to input parameter value uncertainty was also not conducted in this study. As such, simulated responses could change depending on the specific parameter values used, though reasonable values were assumed.

7.0 References

Kaiser-Hill (KH). 2002. Site-Wide Water Balance Model Report for the Rocky Flats Environmental Technology Site. May.

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